BULK COMMODITY TRANSPORTATION IN THE UPPER MISSISSIPPI RIVER VALLEY

PREPARED FOR THE UNITED STATES
ARMY CORPS OF ENGINEERS

by

THE DEPARTMENT OF AGRICULTURAL AND
APPLIED ECONOMICS
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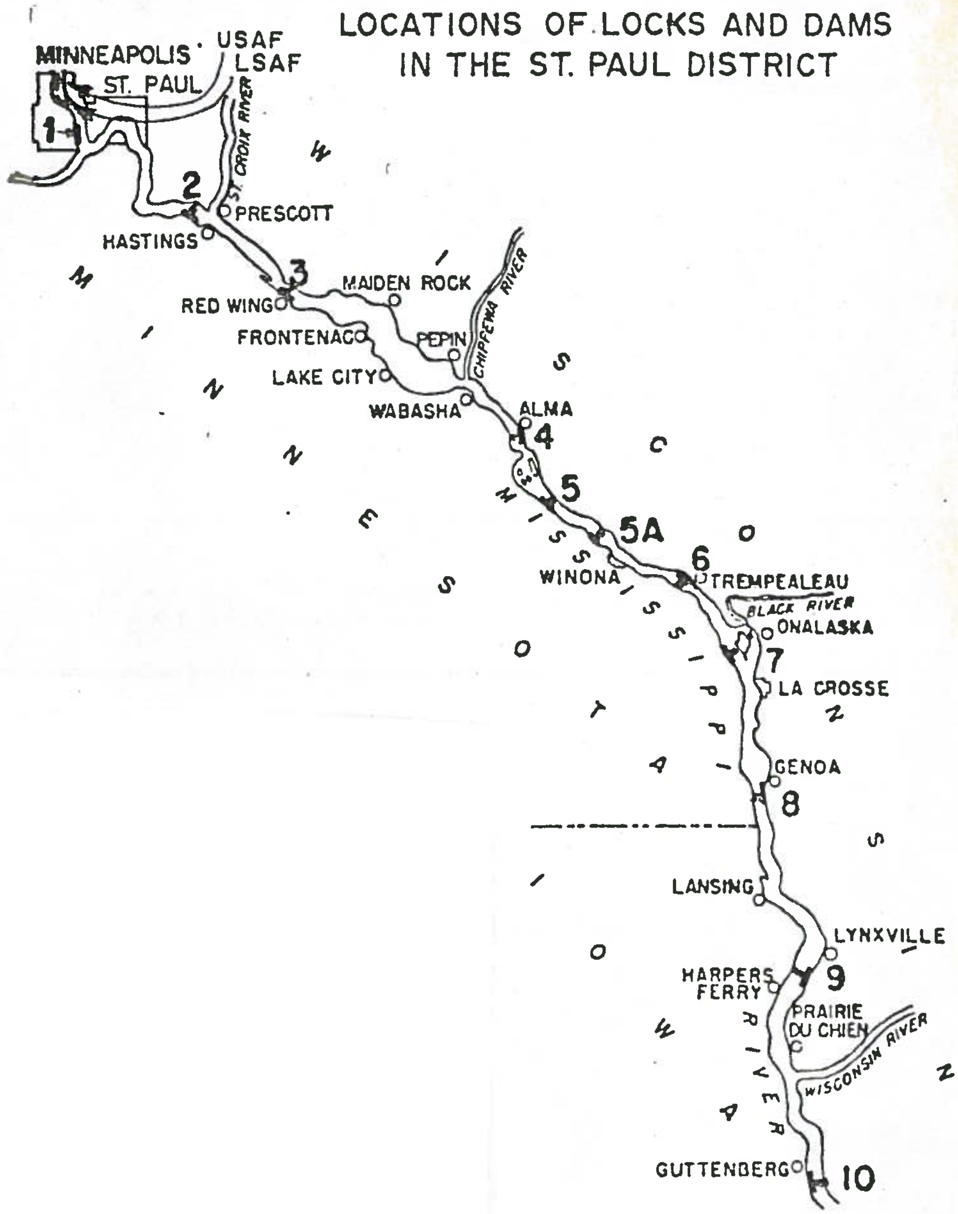
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FOREWARD

This report is the first part of a two-part study of the future competitiveness of waterborne commerce. It reviews existing data and reports on the movement of bulk commodities in the Upper Mississippi River Basin. It evaluates the adequacy of these data and makes recommendations for further data collection and research to complete the second part of the study.

The overall objectives of the two-part study are to determine the future competitiveness of waterborne commerce in the movement of bulk commodities, and the economic and social impacts on the region and on other modes of transportation of possible closure of the 9-foot channel of the Upper Mississippi.

Analysis is required to determine future shares of commodity transportation. Past studies have generally assumed that riverborne commerce would retain its same relative share of future traffic along with rail, truck, and pipelines, or that total traffic would increase directly with grain shipments. Thus, projections of commodity movements have generally been based on historical trends.

However, changes have recently occurred which could substantially influence the transportation network in the Upper Mississippi River Basin. These include:

(1) increased export demand for grain, along with increased variability in this demand

(2) the introduction of Montana coal for downstream movement, with a

corresponding decline in upstream movement of Illinois coal,

(3) financial problems of railroads,

(4) reduction in amount of crude oil available from the area's only crude pipeline, and

(5) the impact of the energy crisis on the various transportation modes. Consequently, it is necessary to assess the impact of these factors and others to determine "the future competitiveness of waterborne commerce."

The study, the first part of the two-part study, is organized into eleven chapters. Chapter one discusses transportation costs generally and the difficulties and pitfalls of attempting to compare costs of the different transport modes. Chapters 2 through 5 each discuss the cost structure, recent cost studies, and actual costs and capacities of a different transport mode -- water, rail, truck, and pipeline.

Chapter six covers the important area of auxiliary costs. These are the necessary costs, such as for handling and transferring commodities at terminals and between modes. Any statement of the cheapest or best way to transport commodities must consider these costs. Chapter seven compares the cost structures of the four bulk commodity modes and delineates the type of commodities, distances, and situations for which each is best suited.

Chapter eight compares the energy requirements for each mode and discusses some of the environmental factors associated with various modes.

Chapter nine provides a summary of the historical movement of bulk commodities in the region. Chapter ten then reviews the existing projections of bulk commodity movements in the region.

Chapter eleven summarizes the findings of the study. It considers the adequacy of existing data for analyzing the impacts of the 9-foot channel on the Upper Mississippi River Basin and the interrelation of barge transportation with other modes of transportation.

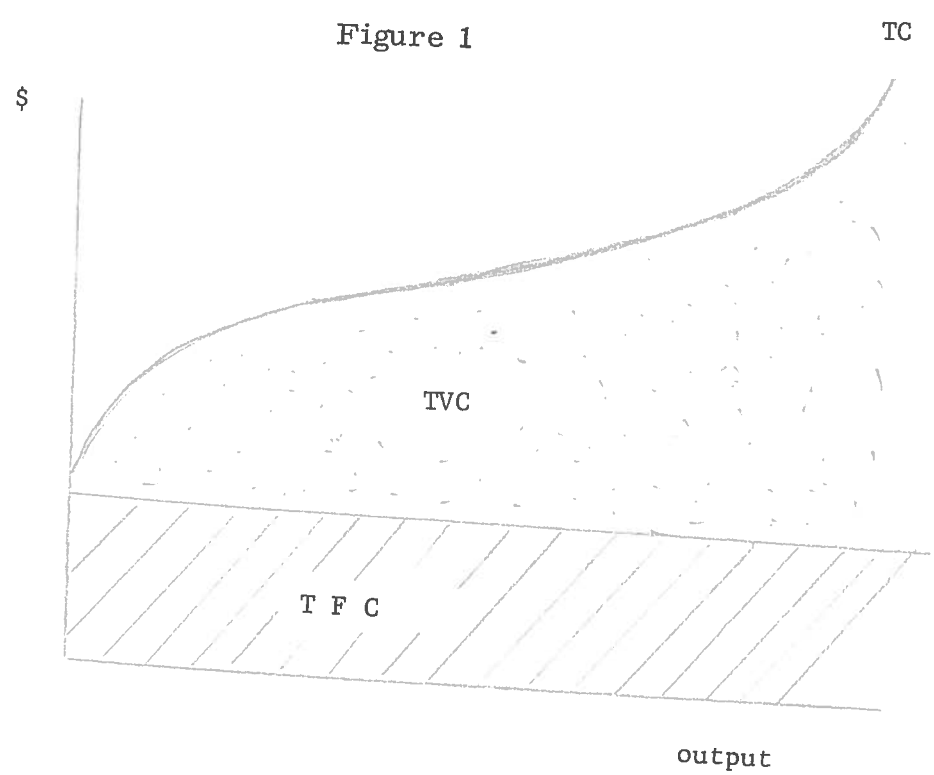
CHAPTER I

COST CONCEPTS

In economic literature cost analysis is typically conceived in relation to time. Thus, we have short-run vs. long-run analysis. Short-run cost analysis assumes plant size is fixed, whereas long-run analysis assumes a choice in plant size and hence relates to planning scale or size of operation.

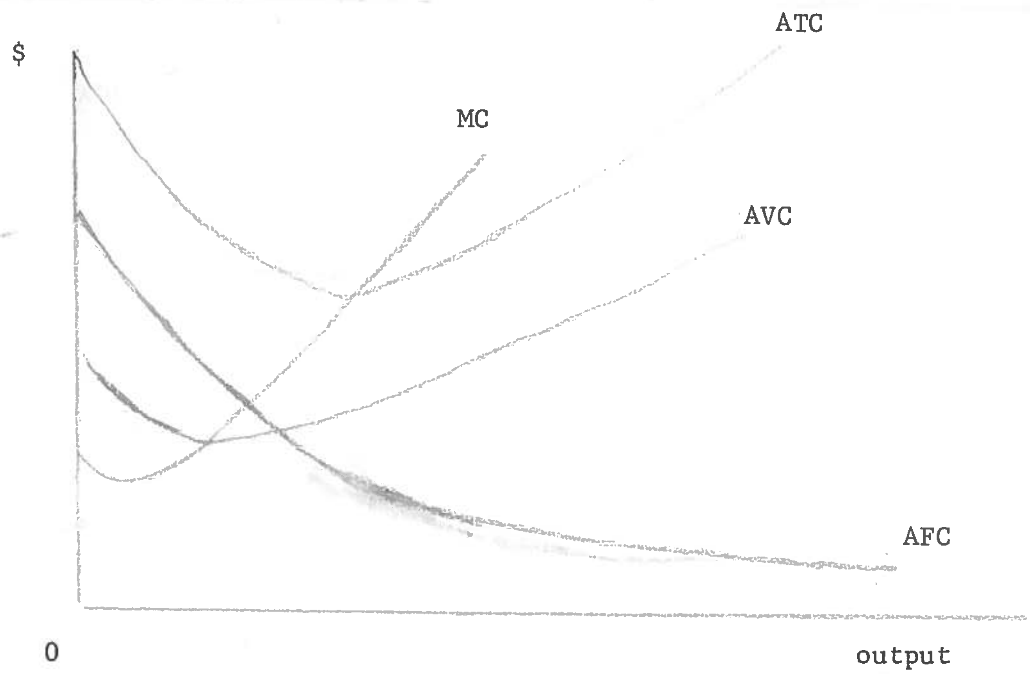
Short-run cost analysis typically classifies costs on the basis of whether they are a function of or are related directly to output. Costs that are a function of output are termed variable costs, while costs unrelated to output, i. e., they go on whether or not any output is produced, are termed fixed. Thus, a typical short-run cost model analyzes costs in terms of Total Fixed Costs, Total Variable Costs and Total Costs (TFC + TVC).

Figure 1



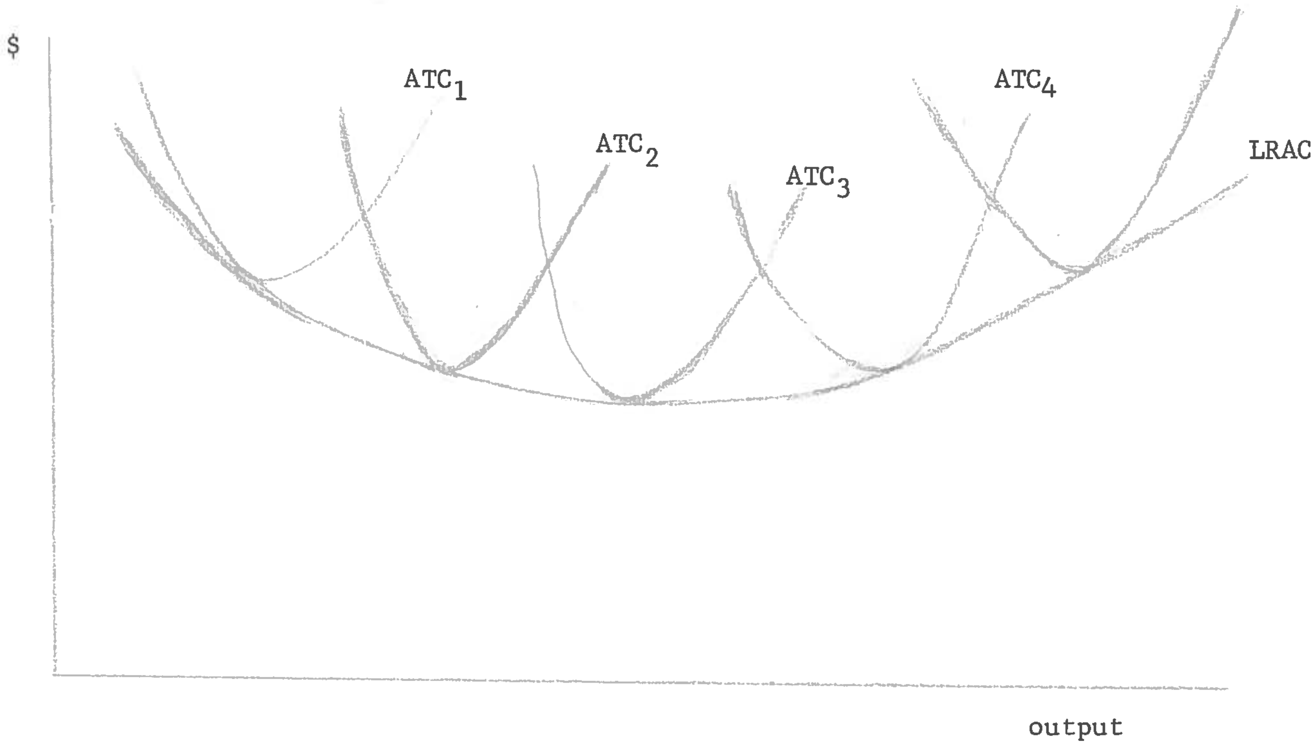
Often, short-run cost analysis proceeds by dividing the above categories of costs by corresponding outputs to obtain average total costs (ATC), average variable cost (AVC) and average fixed costs (AFC). This model usually incorporates another cost concept, which is $\frac{\Delta\ TC}{\Delta\ output}$ or $\frac{\Delta\ TVC}{\Delta\ output}$ or marginal costs (MC).

Figure 2



In long-run cost analysis, all costs are essentially variable since plant size is not fixed, i.e., there is a choice in size of plant. In essence, then, the long-run average cost curve is a planning curve that envelopes numerous short-run average total cost curves and shows whether increasing, constant or decreasing cost economies to size of plant exists.

Figure 3



This short exposition has been presented to emphasize that the literature in transport cost analysis does not consistently follow the cost models portrayed above. The lack of consistency creates difficulties in making meaningful comparisons within and between transportation modes. For example, variable costs in the ICC scale include 80 percent of freight operating expenses, rents and taxes (exclusive of federal income taxes) plus an allowance for the cost of capital before federal income taxes on 50 percent of the road property and 100 percent of the equipment used in freight service -- a mixture of fixed and variable costs in conventional economics. Moreover, non-conventional cost terms are used in transport cost literature, and one cannot be sure what these terms mean without a careful check of the reports that use them. For example, the term "operating expenses" is frequently used, and without further investigation there is no way of knowing whether this term is consistent with conventional "variable" costs. The term "incremental" costs is used in transport cost literature and, again, without further checking one cannot know whether that term is consistent with the conventional "marginal" costs. Transport cost literature also uses the term "fully allocated" costs, and it is not apparent whether that term is synonomous with the conventional "total costs." The point is: To be able to make meaningful intra- and intermodal cost comparisons, cost terms must have the same meaning.

Another warning flag in searching transport cost literature is to be sure to distinguish between rates, which are costs to users of transport services, and actual costs of owning and operating the transport media that provide these services.

A literature search of transport costs soon reveals considerable variation in the unit used for cost analysis. Some studies use cost per bushel; some use costs per ton. Others use cost per ton-mile. This variation makes it difficult, if not impossible, to compare intra-modal and inter-modal cost studies or reports. Moreover, lengths of haul and utilization levels (which include various assumptions about backhaul) often vary from study to study so as to make it difficult to make meaningful comparisons. In addition, within each transportation mode, alternative techniques are usually available for moving a given tonnage, and each technique gives rise to differences in costs. For instances, in rail transport wheat can be transported in single or multiple car shipments, in boxcar or hopper car, in conventional train or unit train, all with different cost for moving the same tonnage. This approach is appropriate if the objective is to determine the least cost technique for moving a given tonnage of wheat over a certain geographical distance, but may be inappropriate for other objectives.

Some transport cost studies are based on sample survey data, while others are based on synthesized or engineering data. Costs can differ because of these differences in data sources. Engineering data will often show lower costs than sample survey data.

Finally, transport firms that provide different kinds of services, such as a rail firm that provides freight and passenger service, create real costing problems for the analyst. Any procedure for allocating fixed costs among services is completely arbitrary, and hence costs can vary because of differences in fixed cost allocating procedure. For this reason, some analysts argue that it may be meaningless to price transport services on the basis of average total costs or total costs. These analysts suggest the use of variable costs as a basis for pricing decisions, keeping in mind that variable costs reflect a lower boundary. In the long-run, a business firm must meet its total costs to stay in business. This does bring up another related issue, and that is the variation in extent of public subsidy. The variation in subsidy may mean that cost differences exist among modes due only to differences in subsidies.

These, then are some of the cautions to keep in mind in reviewing cost studies or in analyzing costs.

CHAPTER II

COSTS AND CAPACITIES OF WATER TRANSPORTATION

The U.S. Army Corps of Engineers periodically estimates the costs of operating tow boats and barges. These estimates are not published but are available for Corps sponsored studies and related projects. Estimates are made of hourly operating costs for tow boats by horsepower categories ranging from 500-800 hp to 8100-9000 hp. The 1974 estimates range from $32 per hour for the smallest tugs to $167 for the largest with the operating cost of a 2,200 hp tug estimated at $89 per hour.[1/]

Hourly operating costs for two sizes of open and two sizes of covered hopper barges as well as various tank barges are also estimated. These estimates of hourly operating costs range from $1.35 for a standard 175' by 26' by 12' open hopper barge to $17 an hour for a 280' by 50' by 14' refrigerated cylindrical tank barge used for transporting anhydrous ammonia.

Tables 1 and 2 are illustrative of the Corps cost estimates. These tables are for 1970 but data for later years is available for research purposes.

Donley and Associates are currently analyzing prevailing transportation rates (not costs) for commodities which pass through Lock and Dam 26 at Alton, Illinois. The study has been contracted and is to be completed in the near future.

The "rates" to be analyzed are the charges the shippers actually incur for transportation services from the point of origin to the point of final destination. Three rates for each commodity will be determined. The three are the waterway rate, a rate for an all land route, and a rate for a combination land and water movement. Current water rates will reflect all charges arising from the loading of the commodity at the origin,

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1/ See Tables 8 and 9 for cost factors included in estimates. Barge cleaning costs are not included in these estimates, however.

Table 1

Estimated Hourly Cost of Operating Tow Boats
on the Mississippi River System
January 1970

Horsepower	Hourly Operating Cost (345 days)
500 - 700	$ 29.00
800 - 1,000	33.00
1,100 - 1,200	37.00
1,300 - 1,500	40.00
1,600 - 1,800	45.00
2,000 - 2,200	52.00
2,400 - 2,800	57.00
3,000 - 3,600	67.00
4,000 - 4,400	77.00
4,800 - 5,200	85.00
5,500 - 6,000	93.00
6,400 - 6,600	103.00
7,000 - 8,000	113.00
8,500 - 9,000	125.00

Source: U.S. Army Corps of Engineers.

Table 2

Estimated Hourly Cost of Operating
Barges on the Mississippi River System
January 1970

Type of Barge	Dimensions (Length, Beam, Depth)	Hourly Cost (355 days)
Open	100' x 26'	$ 0.55
Open	135' x 26'	0.75
Open	175' x 26' x 11'	1.00
Covered	175' x 26' x 11'	1.25
Open	195' x 35' x 12'	1.55
Covered	195' x 35' x 12'	1.75
Open	245' x 45' x 12'	2.25'
Cement (self-unloader)	195' x 35' x 12'	5.60
Cement (self-unloader)	290' x 50' x 12'	14.00
Petroleum (tank)	195' x 35' x 12'	2.60
Petroleum (tank)	240' x 50' x 12'	4.00
Petroleum (tank)	290' x 50' x 12'	5.00
Molasses (tank)	195' x 35' x 12'	2.80
Sulphuric Acid (Cylindrical)	195' x 35' x 12'	3.60
Phosphoric Acid (Cylindrical tank)	195' x 35' x 12'	7.20
Chlorine	195' x 35' x 12'	6.50
Caustic soda (liquid)	195' x 35' x 12'	5.00
Sulphur (liquid)	260' x 52' x 12'	10.00
Sulphur (liquid)	295' x 52' x 12'	11.60
L.P.G. or anhydrous ammonia	210' x 44'	8.60
Anhydrous Ammonia	278' x 50' x 14'	19.00
Asphalt (liquid) (short haul)	195' x 35' x 12'	3.75
Asphalt (liquid) (long haul)	195' x 35' x 12'	4.30
Elemental Phosphorus	195' x 35' x 12'	8.60

Source: U.S. Army Corps of Engineers.

transportation to its destination, and unloading at the premises of the consignee under normal conditions. Rates of alternative modes will include all loading, unloading, and switching charges necessary to provide comparable transportation service.

The alternative modes (to water) are those most likely to be used in the absence of waterway capability. If published rates are not available, Donley and Associates are to construct rates which will approximate the charges to the shippers for that movement.

Much of the traffic through Lock and Dam 26 has its origin or destination in the St. Paul District. It is anticipated that the rate information will be useful, both to determine costs of water shipments and to make intermodal comparisons.

Reed, Byrne & Ackley (4) developed a model of a barge line which could service the grain and fertilizer requirements of 14 coops in Illinois, Minnesota, Iowa, and Missouri. Commodities considered in the model were grain (southbound) and fertilizer (northbound). The data on operations and costs of barges and tow boats were obtained from barge manufacturing companies and barge lines for the year 1970.

Total costs (to the model barge firm) were determined to range from 2.31 mills per ton-mile with no back haul to 2.11 mills per ton-mile with 100 percent back hauls. These costs were based on a one-way distance of 1,415 miles for a standard tow which they defined as a 3,200 horsepower tow boat with fifteen 195 by 35 foot barges with rolling covers. (See Table 3). They caution, however, that actual cost reductions due to increased back hauls might be less than indicated. Back hauls may increase turnaround time, add to cleaning costs, and reduce increased northbound speed.

Table 3

Estimated Barging Cost Relationship with Varying Levels of Back Hauls for a Standard Tow 1/

Loaded Back Hauls	Total Cost	Cost per ton	Cost per ton-mile
Percent	- - - - -Dollars- - - - -		Mills
0	68,716	3.26	2.31
10	73,875	3.23	2.29
20	79,034	3.20	2.27
30	84,193	3.18	2.25
40	89,352	3.15	2.23
50	94,510	3.12	2.21
60	99,669	3.09	2.19
70	104,828	3.06	2.17
80	109,987	3.04	2.15
90	115,146	3.01	2.13
100	120,305	2.98	2.11

1/ The back haul was assumed to be the northbound shipment. A linear interpolation was made between calculated values with 0 and 100 percent back hauls.

Source: REED (4).

The cost per ton-mile for a round trip from Minneapolis to New Orleans (a one-way distance of 1.722 miles) with grain down and fertilizer up was 2.17 mills per ton-mile. (Table 4)

Table 4

Estimated Cost of Barging Fertilizer from New Orleans to 4 River Points and Returning with Grain 1/

River Points	Hours per Round Trip	Total Cost	Cost per ton 2/	Cost per ton-mile 2/
		- - - Dollars - - -		Mills
St. Louis	582.3	94,060	2.33	2.22
Peoria	800.4	126,694	3.14	2.52
Minneapolis	959.3	150,470	3.73	2.17
Kansas City	837.3	132,215	4.90	3.42

1/ Estimates based on 1 round trip for 1 standard tow.
2/ Average costs of the complete voyage.

Source: REED (4).

A "standard tow" as defined above was estimated to cost $149.63 per hour to operate. Barging costs are directly related to the time required to complete a round trip. (See Table 5). The time index represents the percentage of time required to complete a round trip as compared to a "normal" trip with tow speeds of 7.5 mph southbound and 4.3 mph northbound.

Table 5

Estimated Barging Costs and Time Relationships for a Standard Tow 1/

Time Index	Hours Per Round Trip	Total Cost	Cost Per Ton	Cost Per Ton-Mile
Percent		Dollars		Mills
90	681.9	108,963	2.70	1.91
95	719.8	114,634	2.84	2.01
100	757.7	120,305	2.98	2.11
105	795.6	125,976	3.12	2.21
110	833.5	131,647	3.26	2.31
115	871.4	137,318	3.40	2.41
120	909.2	142,974	3.54	2.51

1/ Based on one-way distance of 1,415 miles.
Source: REED (4).

Barging costs were inversely related to the one-way distance of a haul. See Table 6. Only one tow speed was used in this part of the analysis so the lower speeds experienced in the upper river systems are not reflected in Table 6.

Table 6

Estimated Barging Costs and Distance Relationships for a Standard Tow

One-way Distance	Hours Per Round Trip	Total Cost	Cost Per Ton	Cost Per Ton-Mile
Miles		Dollars		Mills
800	532.7	86,638	2.15	2.68
900	569.3	92,114	2.28	2.54
1,000	605.9	97,591	2.42	2.42
1,100	642.5	103,067	2.56	2.32
1,200	679.1	108,544	2.69	2.24
1,300	715.7	114,020	2.83	2.17
1,400	752.2	119,482	2.96	2.12
1,500	788.8	124,958	3.10	2.06
1,600	825.4	130,435	3.23	2.02
1,700	862.0	135,911	3.37	1.98
1,800	898.6	141,388	3.51	1.95

Source: REED (4).

Total costs did not include channel dredging and maintenance, dock and dam maintenance, etc.

The capital equipment costs used in the study were:

tow boats (3200 hp)	$1,100,000
tow boats (4200 hp)	1,300,000
tow boats (5000 hp)	1,500,000
barge (195 x 35 ft. with rolling covers)	130,000

Life expectancy estimates for 15 years for tow boats and 20 years for barges were furnished by the manufacturers for depreciation purposes. Straight line depreciation was used in the model. Interest on $\frac{1}{2}$ of the capital investment at 8 percent was included as an expense in the model. Marine insurance was estimated at 10 percent of the capital cost of equipment. Taxes were estimated at 5 percent of the capital cost.

A crew of 11 was estimated to cost $700 per day including fringes. Crew size is 10 to 12 men for most tow boats and is independent of the size of tow. The rule of thumb used for estimating fuel consumption was 1 gallon of diesel fuel per horsepower per 24 hour period. Fuel costs vary according to location. The range of cost per gallon at the time of the study was 10.75 to 14 cents per gallon. Estimated daily fuel costs (at 12 cents per gallon) were $384 for a 3200 hp tow boat and $600 for a 5000 hp tow boat. (Representative fuel costs in 1974 were 31 cents per gallon!)

Supplies (including food) were estimated at $100 per day.

Maintenance and repair costs for a 3200 hp tow boat were estimated at $400 per day and at $600 per day for a 5000 hp tow boat. These estimates include the cost of an engine conditioning every two years at a cost of $25,000 to $30,000. They do not include labor costs of the crew which are included elsewhere.

It was assumed that barge maintenance was insignificant (for barges less than 10 years old).

Administrative costs were estimated at 12.5 percent of operating costs or $97,946 per year for the 3200 hp tow boat and $126,560 for the 5000 hp tow boat. Barge expenses were not included in this compilation. Administrative expenses include office salaries, utilities, building rents, workmen's benefits, etc.

The above operating costs are summarized on an annual daily and hourly basis in Table 7.

Other costs. There are other costs which may be incurred such as fleeting, shifting and the cleaning of barges. Fleeting consists of taking

Table 7

Annual, daily, and hourly costs of owning and operating a 3,200-horsepower and 5,000-horsepower towboat, and a covered dry-cargo barge

Item	Towboats						Barge		
	3,200-horsepower			5,000-horsepower					
	Annual	Daily	Hourly	Annual	Daily	Hourly	Annual	Daily	Hourly
	Dollars								
Depreciation	69,667	199.05	8.29	95,000	271.42	11.30	6,175	17.65	.73
Interest	44,000	125.71	5.22	60,000	171.42	7.14	5,200	14.85	.62
Insurance	110,000	314.28	13.10	150,000	428.57	17.85	13,000	37.15	1.55
Taxes	5,500	15.71	.65	7,500	21.42	.89	650	1.85	.08
Crew labor	245,000	700.00	29.17	245,000	700.00	29.16	-	-	-
Fuel	134,400	384.00	16.00	210,000	600.00	25.00	-	-	-
Supplies	35,000	100.00	4.17	35,000	100.00	4.17	-	-	-
Maint. & repair	140,000	400.00	16.67	210,000	600.00	25.00	-	-	-
Administrative	97,946	279.85	11.66	126,560	361.60	15.06	-	-	-
Total	881,513	2,518.60	104.93	1,139,060	3,254.45	135.60	25,025	71.50	2.98

- = Not applicable.

Source: REED (4).

a barge out of a tow for loading or unloading. Fleeting costs were estimated at $160 per trip per barge for the model used. The study states that a typical charge for fleeting is $35 an hour or sometimes $50 a barge. Shifting is the repositioning of barges within a tow. Shifting costs were not estimated in this study. Cleaning must be done before loading barges with grain if the previous cargo consisted of coal or fertilizer, etc. It takes four men about 2 hours to clean a hopper barge. Estimated cleaning costs for a barge of 200 feet or less with a roll-type cover were:

weekdays	$115
Saturdays	$142
Sundays/Holidays	$170

Estimated tow speeds were:

	Northbound	Southbound
Loaded	4.3 mph	7.5
Empty	8.6 mph	-

Average tow speeds between New Orleans and:

	Northbound	Southbound
St. Louis	4.7	8.8
Peoria	3.9	5.2
Minneapolis	3.9	6.2
Kansas City	3.9	6.2

The only major drawback to this study are that the costs are somewhat dated and will have to be revised. The assumptions appear reasonable as does the model. However, it should be noted that; 1) it is a model for grain and fertilizer only and does not include coal and other bulk commodities, and 2) total costs do not include any public costs such as lock construction or channel maintenance. Given these limitations, the study should be considered as a basis for further modeling.

Schnake and Franzmann (5) developed a linear programming model to analyze interregional flows of grain and flour in the U.S. Costs and flows are based on the 1966-67 crop year.

They determined that published data on costs of service for barge transportation of grain were virtually nonexistent and those data that did exist were too aggregated to use to estimate costs for particular bulk commodities. In addition, they concluded that published tariffs are not as highly correlated with distance as frequently assumed. In their view, the time element, as affected by navigation factors is very important in determining the costs of barge movements.

Cost data were obtained from the Mobile District of the Army Corps of Engineers.[1/] Information on barge operations, etc. was obtained from industry and TVA officials. Table 8 has annual and hourly costs of owning and operating barges of varying horsepower for 1966. Table 9 has annual and hourly costs for owning and operating 195 x 35 foot barges in 1966.

The costs developed by the Corps and used in this study vary from those developed by Reed in the following ways:

a. Depreciation on tow boats is for 20 years instead of 15 years. (Both allow for a 5 percent salvage value.)

b. Interest expense of $5\frac{1}{2}$ percent is included for financing $\frac{1}{2}$ of the tow boat cost externally (instead of 8 percent by Reed).

c. A rate of return on investment of 8 percent is charged for $\frac{1}{2}$ of the cost internally financed. No internal cost of capital was included by Reed as the Internal Rate of Return was one of the decision criteria.

1/ The source cited was "Supplement to the General Design Memorandum, Tennessee--Tombigbe Waterway, Alabama and Mississippi--"Reevaluation of Project Economies." U.S. Army Corps of Engineers, Mobile District, 1966.

Table 8

Total hourly costs for owning and operating towboats, by horsepower rating, 1966

Item	Horsepower rating							
	800	1,200	1,800	2,000	2,200	2,400	3,200	5,600
	Dollars							
Fixed costs:								
Investment	250,000	350,000	500,000	543,500	587,000	630,000	800,000	1,310,000
Ownership costs:								
Depreciation	11,875	16,625	23,750	25,815	27,880	29,925	38,000	62,225
Interest	6,875	9,625	13,750	14,950	16,140	17,325	22,000	36,025
Return on investment	10,000	14,000	20,000	21,740	23,480	25,200	32,000	52,400
Administration	28,445	33,825	41,360	45,555	47,115	48,675	57,265	77,260
Insurance	5,000	7,000	10,000	10,870	11,740	12,600	16,000	26,200
Taxes	1,250	1,750	2,500	2,720	2,940	3,140	4,000	6,550
Total ownership costs	63,445	82,825	111,360	121,650	129,295	136,875	169,265	260,660
Variable costs:								
Wages and fringe benefits	129,420	141,570	158,360	175,100	175,100	175,100	191,130	207,600
Fuel	27,315	41,695	62,120	68,535	75,530	82,520	198,430	183,530
Maintenance and repairs	12,500	17,500	25,000	27,175	20,350	31,500	40,000	65,500
Supplies	5,750	6,500	7,625	8,000	8,375	8,750	10,250	14,750
Subsistence	7,245	8,280	9,315	10,350	10,350	10,350	11,385	12,420
Miscellaneous	2,415	2,955	10,000	10,870	11,740	3,670	4,380	5,050
Total variable costs	184,645	218,500	265,730	292,830	302,375	311,890	365,575	488,850
Total annual costs of operation	248,090	301,325	377,090	414,480	431,670	448,765	534,840	749,510
Total hourly costs of operation	30	36	46	50	52	57	65	91

Source: Schnake and Franzmann (5).

Table 9

Total hourly costs of service for barges, by barge size, 1966

Item	Barge dimensions	
	195' x 35'	250' x 42'
	Dollars	
Fixed costs:		
Investment	76,000	109,615
Ownership costs:		
Depreciation	3,610	5,207
Interest	2,090	3,014
Return on investment	3,040	4,385
Administration	357	515
Insurance	1,520	2,196
Taxes	380	438
Total ownership costs	10,997	15,755
Variable costs:		
Maintenance and repairs	859	1,236
Cleaning costs	643	643
Total variable costs	1,502	1,879
Total annual costs of operation	12,499	17,634
Total hourly costs of operation	1/1.47	2/2.13
	2/1.51	3/

1/ Mississippi River system--using 355 days, or 8,520 hours, of annual operation.

2/ Columbia-Snake Rivers--using 345 days, or 8,280 hours, of annual operation.

3/ Not considered to be used on the Mississippi River system.

Source: Schnake and Franzmann (5).

d. Administrative costs are not a flat rate of 12.5 percent as per Reed but decline from over 11 percent to less than 6 percent of the cost of the tow boat as the size (cost) increases.

e. Insurance is 2 percent of the cost of the tow boat vs. 10 percent and taxes are .5 percent vs. 5 percent.

f. Wages and fringe benefits (and subsistence costs) increase as the size of the tow boat increases. Reed stated that crew size remained relatively constant across tow boats from 1800 hp to 8400 hp.

g. Cleaning costs are included in annual barge operating costs. The annual cleaning costs per barge ($643) included in Table 9 were obtained from 1963 data presented in an ICC hearing and adjusted for a 1966 wage level.

Schnake and Franzmann estimated that barges and tow boats on the Mississippi system run 345 days per year or 8280 hours. Costs for loss and damage in barging were constructed from data on tons of grain lost from barging. Based on 1966 prices this was 20 cents per ton or .6¢ per bushel.

Average time for loading and unloading barges was assumed to be 96 hours. Fleeting costs were assumed to be $480 per round trip on the Mississippi River.

Table 10 gives selected navigational characteristics by waterway and includes average speeds in 1966.

The major drawback of the cost data developed for this study is that they are almost 10 years old. In addition, no attempt was made to determine costs such as channel maintenance.

Table 10

Selected navigational characteristics, by waterway, 1966

River or waterway	Draft	Towboat horsepower	Barges per tow	Load per barge	Towboat speed	
					Upstream	Downstream
	Feet	Horsepower rating	Number	Bushels	Miles/hour	
Columbia River	8.5	2,400	3	45,000	6.2	6.2
Intracoastal Waterway	8.5	1,200	4	31,400	6.0	6.0
Illinois Waterway:						
Above Joliet	8.5	800	3	45,000	3.0	3.0
Below Joliet	8.5	2,200	10	45,000	3.3	4.0
Mississippi River:						
Above St. Louis	8.5	2,200	10	45,000	4.6	6.3
Below St. Louis	6.5	5,600	22	45,000	4.0	10.0
Missouri River:						
Above Omaha	6.5	3,200	8	31,400	3.5	10.0
Omaha to Kansas City	7.0	3,200	8	35,200	3.5	10.0
Below Kansas City	7.5	3,200	8	38,200	3.5	10.0
Ohio River	8.5	3,200	12	45,000	5.3	7.4
Tennessee River						
Above Chattanooga	8.5	800	3	45,000	1/5.3	1/7.4
Below Chattanooga	8.5	2,000	8	45,000	5.3	7.4

1/ Data not available, thus assumed to be the same as "below Chattanooga."

Source: U.S. Army Corps of Engineers as published in Schnake (5).

The types of operating costs developed in this study conform closely with those developed by Reed. However, there are large differences of magnitude in some items (e.g., taxes and insurance) that should be investigated before using either.

Baumel, et. al., (1) considered various transportation alternatives including truck-barge and rail-barge to determine which transportation system would yield the highest net income in a 6-county area around Fort Dodge, Iowa.

Barging costs for 1972 were estimated from Dubuque, Iowa to New Orleans and from St. Louis, Mo. to New Orleans. The cost estimates were obtained from the president and vice president of a large barge company operating on the Mississippi River.

Their estimates of barge operating costs are summarized in the following table.

Table 11

1972 Grain Barge Operating Costs

	Round Trip Cost	Cost Per Ton	Cost Per Bushel	Cost Per Ton-Mile
Dubuque to New Orleans (1450 mi)				
Soybeans	5,881.50	$3.9757	12.6¢	2.74 mills
Corn	5,881.50	$3.9757	11.76¢	2.74 mills
St. Louis to New Orleans (1050 mi)				
Soybeans	3,814.71	$2.7248	8.18¢	2.60 mills
Corn	3,814.71	$2.7248	7.63¢	2.60 mills

Source: Baumel, et. al. (1).

The total operating costs are basically analogous to those computed in the previous two studies but there are basic differences in the method used to construct the costs.

a. A major cost component was "towing cost" per barge mile or ton mile, which was obtained from barge company executives and based on the charter rate for 1972. This estimate of "towing cost" would include most if not all of the tow boat costs used in the Reed (4) and Schnake (5) studies, i.e., depreciation, insurance, taxes, administration, wages and supplies. The authors justify the use of charter rates rather than costs on the grounds that good cost estimates are difficult to obtain and that charter rates closely reflect operating costs because of competition in the towing industry.

b. Towing costs were different between the reach from Dubuque to St. Louis and the reach from St. Louis to New Orleans because of different size tows and tow boats. The upper reach assumed a 3200 hp tow boat with 10 barges while the lower reach assumed a 7500 hp tow boat with 35 barges. Towing charges were 1.5 mills per ton-mile loaded southbound and 75¢ per barge mile empty northbound on the Dubuque-St. Louis reach. Towing charges on the St. Louis to New Orleans reach were .5 mills per ton-mile loaded southbound and 65¢ per barge mile empty northbound.

c. It was assumed that there were no back hauls as the industry sources advised that barge back hauls do not pay on an incremental basis as the time lost waiting for a back haul is approximately 18-20 days.

d. The daily and hourly operating costs for a 195 x 35 foot covered hopper barge was computed to be $38.52 per day or $1.60 per hour. The barge cost was $125,000 which was converted to an "annual equivalent" cost. Useful life was 23 years and interest rate was 10 percent.

This study uses relatively current data. However, it relies on charges as proxies for costs in the key area of tow boat operating expenses. As in Reed (4) and Schnake (5) costs of channel and lock maintenance are not considered. The fleeting at St. Louis to obtain the lower operating costs of large tows on the Lower Mississippi might be more realistic for a general model of barge transport than the above studies.

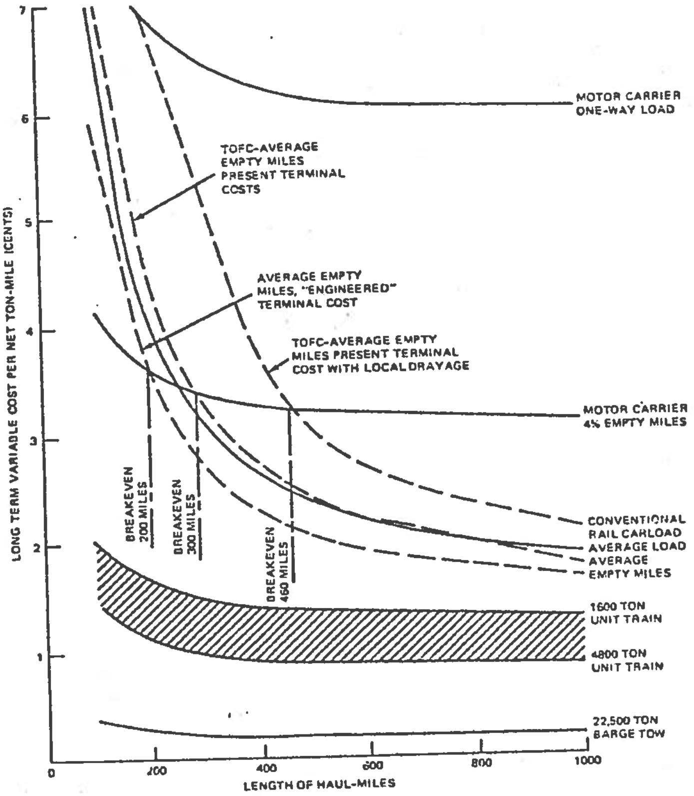
Appendix F to Volume I of the United States Railway Association's Preliminary System Plan (7) compares "engineered" full economic costs rather than historical average costs. These costs are displayed in figure 1. These "full economic costs" incorporate estimates of costs based on current replacement costs and interest rates. The authors state that these are "estimates of true long-run costs, appropriate for investment planning.

Appendix H to Volume I of (7) discusses government assistance to the various modes of transportation including barge traffic. Appendix H states:

> "Recent unpublished government studies on the question of user charges project that recovering only maintenance and operations costs would divert approximately 15 percent of the traffic from Inland Waterways. Part of this tonnage would move by rail or pipelines while some of it would cease moving. Recovering these expenditures from the remaining 85 percent of the traffic would require an average of .6 of a mill per ton-mile user charge, an increase of 19 percent. In most instances the entire user charge would be passed on to the shipper, though in some cases the barge operator would absorb part of the cost."

Figure 1

COMPARATIVE LINE-HAUL COSTS
FULL ECONOMIC COST BASIS



NOTES: 1. FULL ECONOMIC COSTS BASED ON PRESENT DAY EQUIPMENT REPLACEMENT COST, 10% CAPITAL COST, NO PROVISION FOR INCOME TAXES

2. NO ALLOWANCE FOR CIRCUITRY IN LENGTH OF HAUL

Source: Preliminary System Plan (6).

Table 12

Tolls Required to Recover Costs of Operations and Maintenance, 1968

River District	Toll
Lower Mississippi (below St. Louis)	.1 mill per ton-mile
Ohio River	.4 " " "
Illinois Waterway	.6 " " "
Upper Mississippi (above St. Louis	.8 " " "
Kanawha River	.9 " " "
Mononghela	1.1 " " "
James River	1.6 " " "
Allegheny	15.1 " " "

Source: Preliminary System Plan (7).

The study referred to is an unpublished Department of Transportation document entitled User Charges on the Inland Waterway System, dated January 1971. This same study estimated the level of tolls necessary to recover operations and maintenance costs. These costs are presented in Table 12. These figures are based on 1968 costs and traffic levels. (1968 O & M costs for the Mississippi north of St. Louis were $7,643,440, and total ton-miles were 60,746,000.

Appendix H further states:

> "The National Waterways Conference, Inc. (NWC) estimated that a user fee designed to collect an annual sum of $150 million would eliminate one-third of the traffic on the waterways. This is about one-half the total federal expenditures for capital projects, operations and maintenance in 1972.
>
> In supporting its projection, NWC estimated that such a fee would raise cost one mill per ton-mile, or 25-50 percent for 150 billion ton-miles of waterways traffic. Most of such increases would be reflected in higher rates. NWC also suggested that, for high-cost low-volume segments, as much as 50 percent of the mileage would have to be closed. 2/ While some of this tonnage would cease moving and some would move by pipeline, a major portion of the tonnage in question would move by rail.

Appendix H concludes that although waterways might lose a substantial part of their present traffic, much of the retained traffic would be on the lower Mississippi which has high volume and low operation costs. A disproportionate amount of the waterway's lost traffic would be in the Northeast Region served by the bankrupt railroads.

Table 12 indicates that although the Upper Mississippi would require substantially higher tolls than the Lower Mississippi, it does not have the high O & M costs associated with rivers in the area being discussed.

2/ The Impact of Waterway User Charges-An Industry-by-Industry Assessment, National Waterways Conference, Inc., Washington, D.C., 1968 as cited in Department of Transportation, User Charges on Inland Waterways.

The National Water Commission (6) estimated the cost to the Federal Government of operating and maintaining the shallow draft inland waterways at the somewhat lower figure of .4 mills per ton-mile. This estimate was based on average expenditures and traffic for 1968-72. In contrast to the prediction of traffic loss by the USRA study the latter report stated:

> "Although numerous statements were made at the Commission's regional conferences to the effect that user charges would seriously reduce or even eliminate the use of inland waterways, no solid evidence was offered in support of such statements."

Waterway Capacity

The actual capacity of the waterway - the ability to move goods and commodities over given waterway systems is extremely difficult to measure. Capacity of a waterway is a function of such interrelated variables as:

1. The number, size and characteristics of the available barges.
2. The number and horsepower of available tow boats.
3. The physical constraints of the river system including capital structures such as locks, dams, and bridges as well as the channel depth, width, curvature, ect.
4. The size and type of terminal facilities and their respective capacities and capabilities.
5. Number, location and size of fleeting areas.
6. The availability of compatible backhauls and the amount of time required to obtain backhauls.
7. The natural variations in the river due to seasonal conditions, i.e., ice, floods and low water.
8. Other river traffic.
9. Availability of manpower for crews.

There is a wide range in the extent to which these factors can be changed or adjusted and the speed with which adjustments can be made. Tow boats and barges can be moved from one part of the inland water system to another fairly rapidly, increasing capacity on one reach and decreasing it on another. However, there are only so many barges and tows at a given time on the entire system. Any expansion of that number requires new construction over and above the number of barges retired. Expansion due to new construction is not instantaneous as current lead times for new barges are a year or more and even longer for tow boats.

Comparing the total number of barges and tow boats over time, although indicative of changes in capacity, presents problems as their size and characteristics can influence capacity. The trend of increasing average size and power of tow boats theoretically will increase system capacity because of increased speed, and faster manuevering. However, increased size (draft) can also restrict boats from operating in parts of the river system and thereby reduce the flexibility of waterway operators in those parts of the system.

Tables 1 and 2 contain the numbers and sizes of selected categories of equipment for recent years. (Table 1 includes the Great Lakes and Atlantic and Pacific Coasts as well as the Mississippi River System and the Gulf Intra-coastal Waterway. Table 2 includes only the Mississippi River System, and the Gulf Intra-coastal Waterway.)

Eighty percent of the barge fleet and nearly 60 percent of the tow boats and tugs operate on the Mississippi River System and Gulf Intra-coastal Waterway where depths are at least 9 feet. Total barge capacity is increasing both in terms of numbers of barges and in the average size of barge. The number of dry cargo barges increased almost a third from 1962 to 1973 while total dry cargo capacity increased over 60 percent. Dry barges can be used for a number of different commodities so that competition for barges for commodities may limit the number of barges (and capcity) available for a given commodity such as grain, coal or fertilizer.

Transportation in Rural America (9) quotes a barge industry source as

Table 13 INLAND WATERWAY FLEET, SELECTED YEARS, 1962-73[1/]

	Type of vessel									
				Non-self-propelled						
	Towboats and tugs			Dry cargo, barges & scows			Tanks & barges		Total	
Year	Number	Horse-power (thou-sand)	Aver-age horse-power	Number	Aver-age net capacity (tons)	Total net capacity (1,000 tons)	Number	Total net capacity (1,000 tons)	Number	Total net capacity (1,000 tons)
1962	4,253	2,886	679	14,220	917	13,034	2,661	4,052	16,881	17,086
1964	3,994	2,859	716	14,432	970	14,009	2,649	5,163	17,081	19,173
1966	4,054	2,980	735	14,241	1,026	14,608	2,548	4,946	16,789	19,554
1968	4,248	3,708	873	15,379	1,096	16,859	3,001	6,794	18,380	23,652
1970	4,230	3,955	874	16,439	1,112	18,272	3,185	6,330	19,624	24,602
1972	4,278	4,302	1,006	17,527	1,125	19,711	3,420	7,487	20,947	27,197
1973	4,064	4,448	1,094	18,804	1,135	21,343	3,313	7,408	22,117	28,751
Percentage change 1962-73	-4.4	54.1	61.1	32.2	23.7	63.7	24.5	82.8	31.0	68.3

1/ Data are reported as of January 1.

Source: Based on the American Waterway's Operators, Inc., Inland Waterborne Commerce Statistics, 1967, 1969, and 1972 and 1973, Washington, D.C.

Table 14 MISSISSIPPI RIVER SYSTEM AND THE GULF INTERCOASTAL WATERWAY

Year	Type of vessel: Towboats and tugs: Number	Towboats and tugs: Average horsepower	Towboats and tugs: Total horsepower (000)	Non-self propelled: Dry cargo, barges & scows: Number	Dry cargo, barges & scows: Average net capacity (1,000 tons)	Dry cargo, barges & scows: Total net capacity (1,000 tons)	Tanks & barges: Number	Tanks & barges: Total net capacity (1,000 tons)	Total: Number	Total: Total net capacity (1,000 tons)
1971	2,344	983	2,305	13,318	1,116	14,863	2,581	4,753	15,899	19,617
1972	2,427	1,050	2,549	13,985	1,139	15,934	2,788	5,591	16,773	21,526
1973	2,293	1,157	2,654	14,904	1,160	17,293	2,697	5,482	17,601	22,775

Source: Inland Waterborne Commerce Statistics, The American Waterways Operators Inc., 1971, 1972, 1973. Washington, D. C.

estimating that there were about 5,500 barges suitable for hauling grain with about 800 more reportedly on order for delivery in 1974.

Many covered hopper barges can carry 1,500 tons of grain when fully loaded or about as much as 30 conventional rail cars. However, capacity of a barge is dependent on the depth of a channel, for a barge capable of handling 1,500 tons in 9 feet of water would be limited to less than 1,100 tons in a 7ft. waterway. On the other hand, barges with a capacity of 3,000 tons of grain are in use on the wider and deeper waterways. However, barges of that size cannot normally operate on the Upper Mississippi because of their size and are an example of an increase in size that does not add to capacity on a given reach.

The number of tugs and tow boats actually decreased from 1962 to 1973 although total horsepower increased by over 50 percent and average horsepower by over 60 percent.

One measure of the capacity of any system whether it will be a waterway or a production line is obtained by measuring its actual performance over a time period (as opposed to compiling engineering estimates of theoretical capacity). This procedure provides the advantage of knowing that the level of capacity can be attained if conditions do not change, although one cannot normally ascertain how close the system is to true maximum capacity. Figures 1 and 2 illustrate actual receipts and shipments for key commodities from 1940 to 1970. Annual volumes have generally continued to increase.

The actual capacity approach was used by the authors of Grain Transportation in Minnesota (3) in their discussion of the total grain handling

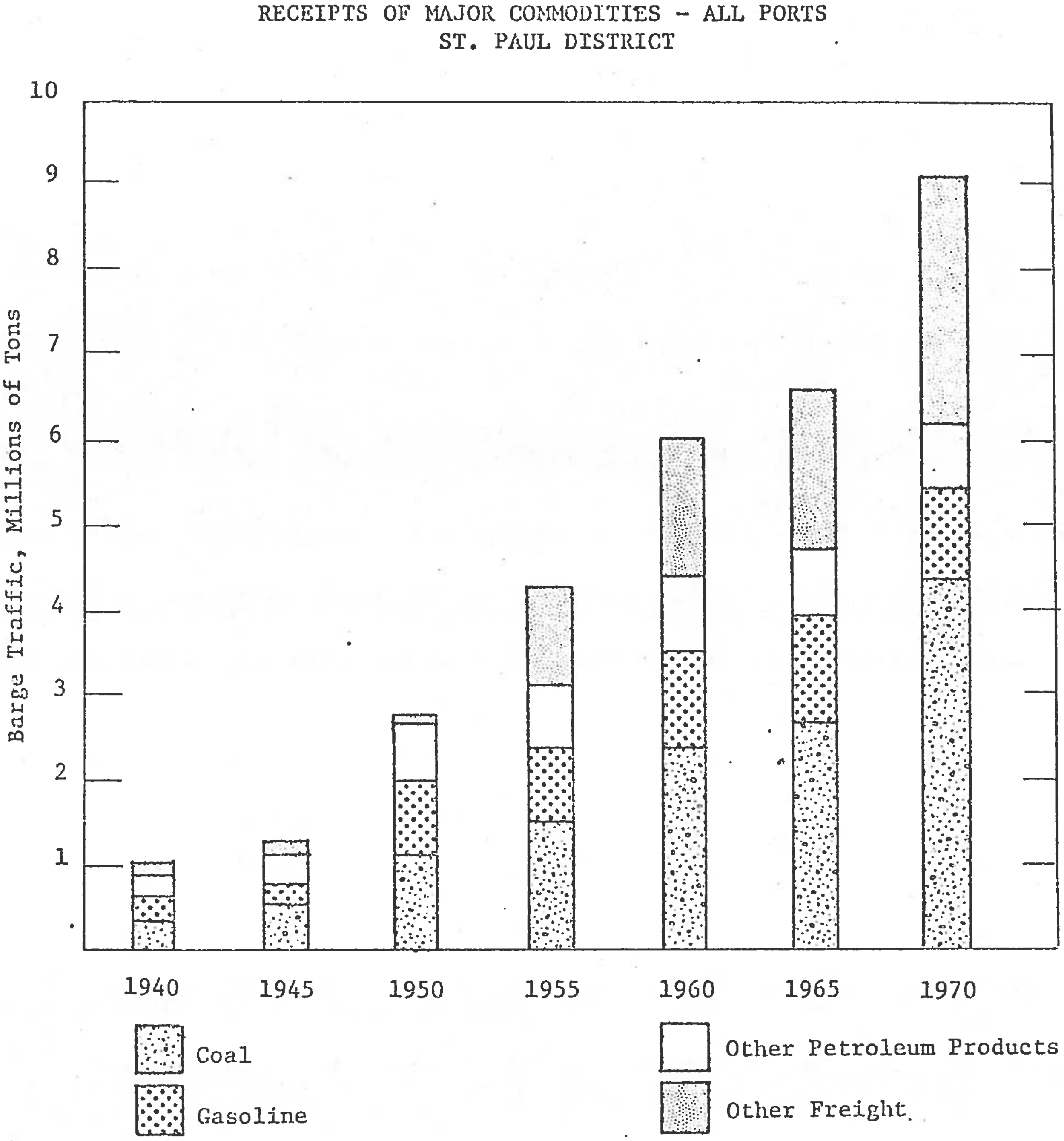


Figure 2

Source: U.S. Army Corps of Engineers (8)

RECEIPTS OF MAJOR COMMODITIES - ALL PORTS
ST. PAUL DISTRICT

SHIPMENTS OUT OF THE ST. PAUL DISTRICT

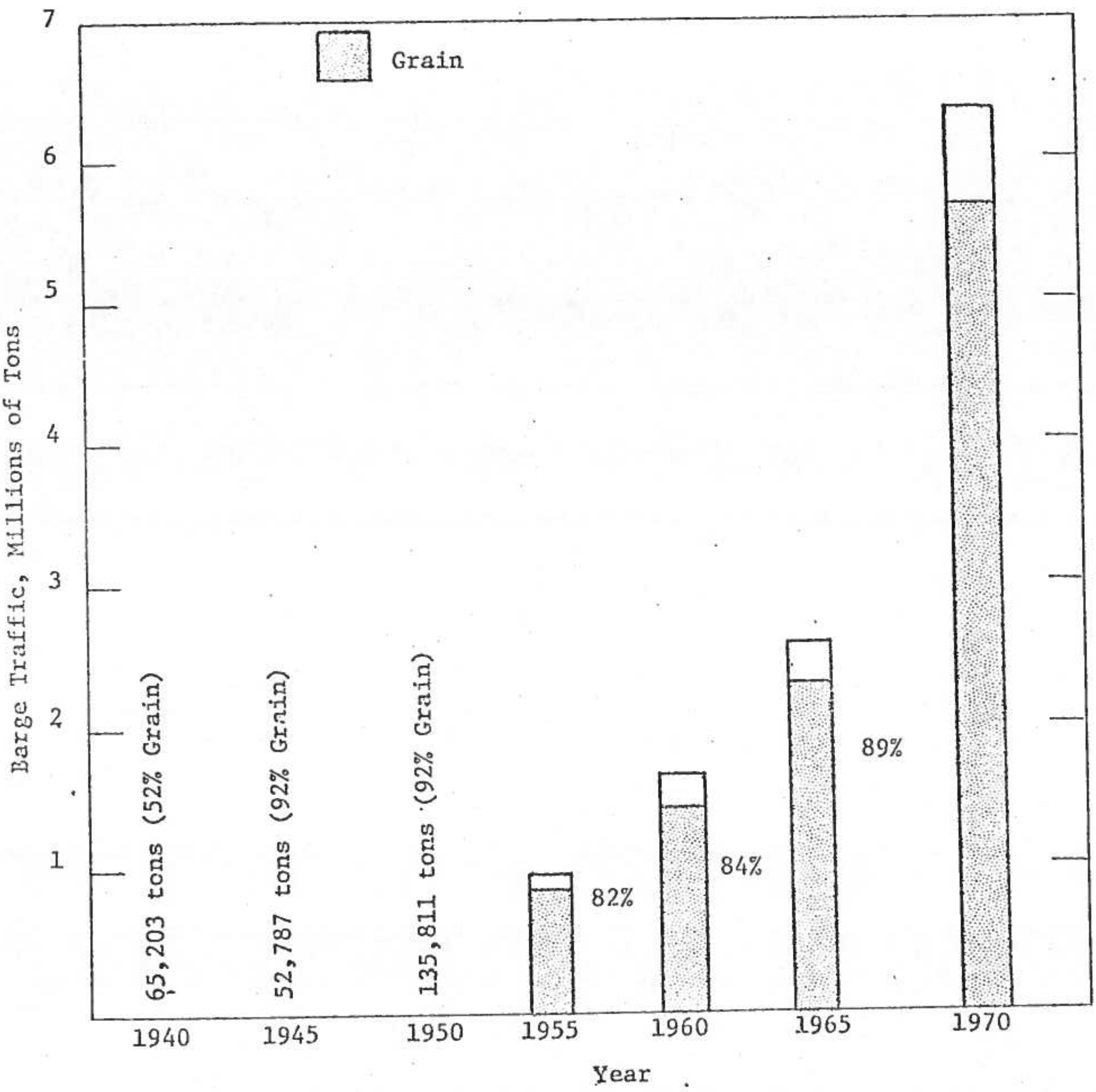


Figure 3

Source: U.S. Army Corps of Engineers (8)

SHIPMENTS OUT OF THE ST. PAUL DISTRICT

and shipping capacity of Minnesota and the Twin Cities. Since their interest was grain, they were considering the shipment of downbound commodities which historically has been less than receipts of upbound commodities in the St. Paul District. However, they reach the following conclusions when discussing shipping capacities:

> "The demand for barges for the shipment of grain on the Mississippi River may exceed what is available. Certain conditions exist that limit the number of barges available in the Minneapolis-St. Paul area.
>
> Navigation of the Upper Mississippi terminates during the winter months, thus shipments of grain from the Minneapolis-St. Paul area ports are limited to nine months of the year...
>
> Another problem facing grain shippers on the Mississippi River is the limits placed on shipping caused by the navigation system itself. There are 28 lock-and-dam structures between Minneapolis and Alton, Illinois. The size and structure of these locks place a limit on the freight-carrying capability of the system. During peak grain shipping periods, bottlenecks at these locks result in slower shipments of grain from Minneapolis-St. Paul area ports. Although efforts have begun to improve this system, they have been met by resistance from environmental groups.
>
> Closely related to the problem of lock-and-dam size is the controversy surrounding the dredging activities of the U.S. Army Corps of Engineers. In order to maintain the Mississippi River channel at nine feet, the Corps of Engineers must continually dredge the river. In recent years, this dredging policy has been challenged by environmental groups. The controversy has centered on the deposition of the dredged materials...
>
> A final factor that limits the number of barges available for the shipment of grain on the Mississippi River is upbound traffic to ports in the Minneapolis-St. Paul area. Receipts in these ports consist principally of coal, fertilizer, iron and steel products, petroleum and petroleum products, non-metallic minerals and agricultural and industrial chemicals. Upbound receipts of coal from Kentucky and Illinois increased steadily until the late 1960's. Conversion of regional coal using facilities to low-sulfur coal from western states resulted in a sharp decline in upbound waterborne coal movements in the past few years. In addition, there has been a substantial increase in shipments of lower-sulfur coal downstream from Minneapolis. Downbound shipments of this type of coal are likely to increase if the proposed Pigs Eye coal handling facility is established.
>
> Any increase in downbound shipments from the Minneapolis-St. Paul port of commodities other than grain may cause a shortage of barges for grain shipping unless it is offset by substantial increases in the upbound shipment of such commodities as fertilizers...

It appears that the present system of waterborne transportation on the Mississippi River will handle only small shipping increases. If substantial increases in grain production occur in Minnesota and surrounding states, other means of shipping the larger quantities of grain will have to be found unless changes are made in the Mississippi River navigation system." (3) p. 71-74.

Another constraining factor influencing annual capacity is flooding, which may shut down or hamper barge operations for up to several weeks.

Carroll, Strikanth and Wilson (2) discuss improving the efficiency (and consequently increasing the capacity) of the inland waterway system. Although the traditional means of increasing efficiency has focused on structural improvements such as bigger, better and more expensive locks, they conclude that various inexpensive operational changes can significantly improve the system efficiency.

They point out that specific points on the system such as Lock and Dam 26 above St. Louis and Locks and Dams 52 and 53 on the Ohio River are apparently saturated with traffic. Waiting time consumed in the queue at these points imposes large financial penalties on the waterway users and ultimately upon the consuming public. However, the authors point out that construction of new locks is not necessarily the most cost effective way to solve the problem. Each year that the proposed $250, 000, 000 replacement of Lock and Dam 26 can be postponed will result in an estimated savings of $16. 5 million in interest costs to the public.

Referring to an example using a switchboat or some other method to properly configure tows forlocking prior to entering the vicinity of the lock, Carroll et al state:

"a hypothetical lock with a given mix of single, double and setover lockages can pass 13.2 tow-equivalents of tonnage per day with average delays of one hour per tow. If the inefficiencies due to double lockages and setovers are eliminated, the simple single-server queuing model predicts that the same lock can pass 55 percent more tonnage while still retaining the same level of average delays.

This example has made no use of improvements in three other potentially fruitful areas:

1. improved barge utilization (decreased percentage of empties)
2. increased number of barges per tow
3. reduced entry time."

Other ways to reduce locking times without major capital expenditures include:

a. changing the characteristics of the lock approach area

b. improvements in lock operations via staffing changes, maintenance procedure changes, and/or positioning of controls, etc.

c. changing locking order

d. institute charges for "inefficient" users.

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CHAPTER III

COSTS AND CAPACITIES OF RAIL TRANSPORTATION

Operating or Variable Costs or Expenditures

In their analysis of alternative grain transportation systems, Baumel et al (1) provide information on transportation rates (cents/bu.) for alternative modes (Table 1). The study compares published rates with estimated variable

Table 1

Estimated Variable and Fully Allocated Costs of Shipping Corn in Box and Hopper Cars from Fort Dodge, Iowa to Selected Markets by Size of Shipment and Published Rates in Cents per Bushel, 1972

Shipment Size	Market	Published Rate	Estimated Cost: Variable Box	Estimated Cost: Variable Hopper	Estimated Cost: Fully Allocated Box	Estimated Cost: Fully Allocated Hopper
Single-Car	Omaha	13.44	16.70	10.25	18.44	11.98
	Kansas City	18.76	20.09	13.17	22.74	15.82
	Pekin	19.32	21.65	14.44	24.63	17.42
	Chicago	14.00	14.51	10.17	17.51	13.18
	Milwaukee	14.00	16.51	11.89	19.98	15.36
	St. Louis	22.12	23.95	16.46	27.74	20.24
	Gulf	25.76	33.61	26.15	40.92	33.45
	Seattle	84.84	54.11	41.87	66.76	54.53
3- to 10-Car	Gulf (1)	23.52	--	23.53	--	29.87
	Seattle (2)	38.92	--	37.59	--	49.26
50-Car	Chicago	12.04	--	8.75	--	11.58
	Milwaukee	12.04	--	10.23	--	13.48
	Gulf	21.84	--	22.34	--	28.68
115-Car	Gulf (3)	17.00	--	18.74	--	23.86

(1) This is the published 3-car rate.
(2) This is the published 5-car rate.
(3) As indicated in a previous section, this rate is not presently available to stations in Iowa; the rate shown has been estimated from a published rate available to Illinois stations.

Source: Baumel et al (1)

costs for 1972 of shipping corn in box and hopper cars from Ft. Dodge, Iowa to selected markets by size of shipment. For single box car shipments, variable costs exceed published rates for all destinations given except to Seattle. However, variable costs for single hopper car shipments are below published rates for all destinations except the Gulf market. For 3 to 10 box car shipments, variable costs (23.53¢) equal published rates to the Gulf, but to Seattle, variable costs are estimated to be slightly below published rates. For 50-car shipments, variable costs are less than published rates to Chicago and Milwaukee, but slightly more than published rates to the Gulf. For 115-car shipments by hopper car to the Gulf, variable costs (18.74¢), also in this instance, are slightly above published rates.

Baumel et al also provide information on variable costs of moving corn from Ft. Dodge to New Orleans by inter-modal combinations (Table 2). Of these combinations, rail-barge (March-November) using hopper cars has lowest costs (23.71¢ per bu.), while belt-barge (March-November) has the highest (36.96¢ per bu.). Baumel et al use ICC cost coefficients based on Rail Form A.

Baumel and Wallize (2) provide information on average rail hopper car repair costs, based on data from car builders. The average repair costs for a firm operating its own cars are 1.25¢ per mile for cars running from 50,000 to 60,000 miles per year and 1.8¢ per mile for cars running 15,000 miles per year. Covered hopper cars can also be leased at a cost of $200 to $250 per month, the exact rate depending on supply of and demand for cars.

Table 2

Estimated Variable Costs of Moving Corn from Fort Dodge to New Orleans by Mode in Cents per Bushel, 1972

Mode			Cents per Bushel
Rail			
Single box car			33.61
Single hopper car			26.15
3- to 10-car units in one train			23.53
50-car train			22.34
80-car train (continuous)			19.34
115-car train (continuous)			18.74
Intermodal Combinations			
Truck-barge	March-November (1)		29.70
Truck-barge	December-February (2)		32.77
Rail-barge	March-November (1)	box	27.62
		hopper	23.71
Rail-barge	December-February (2)	box	28.43
		hopper	23.84
Belt-barge	March-November (1)		36.96

(1) Fort Dodge to Dubuque to New Orleans
(2) Fort Dodge to St. Louis to New Orleans

Source: Baumel et al (1)

G. J. Carroll's (3) study yields information on the total variable costs of moving wheat for various distances from Montana and North Dakota to Minneapolis in covered hopper cars. The variable costs in this study reflect costs formulated on the basis of Rail Form A formula, using Great Northern and Northern Pacific combined expenses and performance factors for 1969 and updated to 1974 using an inflationary factor of 45.2%. Variable costs include 80% of freight operating expenses, rents and taxes (excluding federal income taxes) plus a return of 6% after federal taxes on 50% of the road property and 100% of the equipment used in freight service. Variable costs are subdivided into terminal, way train and through train costs and are shown in cents per cwt. Carroll's cost information is very detailed for the specified situations.

J. L. Carroll (4) compared estimated incremental costs of rail and barge transportation between Pittsburgh and Lake Erie, and he compared these incremental costs with rates (Table 3). Costs and rates were measured

Table 3

Comparison of Estimated Incremental Costs of Barge and Rail Transport Between Pittsburgh and Lake Erie

	Barge Costs and Rates			Rail Costs and Rates			
	Loaded Both Ways		Loaded One Way	Loaded Both Ways	Loaded One Way		
	700 hrs/mo	700 hrs/mo Reduced Speeds	700 hrs/mo	700 hrs/mo	700 hrs/mo	550 hrs/mo	515 hrs/mo
Cost Per Ton-Mile (Mills)	2.22	3.06	4.19	0.703	1.24	1.36	1.49
Rate Per Ton-Mile (Mills)	3.22	4.68	6.07	1.085	1.81	2.08	2.36
Rate Per Ton (Dollars)	0.671	0.973	1.10	0.163	0.271	0.312	0.353

Source: J. L. Carroll (4)

in mills per ton-mile with conveyances assumed to be loaded both ways and operating 700 hours/month. Rail costs and rates were also compared under conditions where cars were loaded one way only and with hours/month of operation varying from 515 to 700; incremental costs per ton-mile vary from 1.24 mills at the higher level of operations to 1.49 mills at the lower level. Rates for comparable levels of operation vary from 1.81 mills to 2.36. Both costs and rates are less when cars are assumed to be loaded both ways.

In arriving at the incremental costs of rail movement, Carroll assumed:

A unit train of one hundred, 100-ton hopper cars pulled by four, 3000-H.P. diesel locomotives,

Coal would be available for northbound traffic and iron-ore for southbound when assuming cars were loaded both ways,

The round-trip distance of 300 miles could be run in 15 hours at an average speed of 20 mph.

That 4 hours would be required for loading and unloading, respectively. With loaded movements in both directions, therefore, the total elapsed time by rail would be 31 hours (16 hrs. for loading-unloading plus 15 hours of travel).

Empty back haul assumed one round trip per day, 5 days per week and the 10,000 ton unit train (one hundred, 100-ton hopper cars).

In Appendix C to the study, Carroll describes the procedures followed in developing the costs.

Fedeler, Heady and Koo (8) estimate variable rail costs for single car, multiple 50-car units, 10% increase in single-car costs, 20% increase in single car costs and alternate single car. The single car costs for 1972 are based on 1969 inflated variable costs for which the source was "Rail car load cost scales by territories for the year 1967, Bur. of Acct. Statement No. 1C1-69, Washington, D. C., July 1971," ICC, Bur. of Acct., Washington, D. C., 1972. Rail costs (¢/cwt.) of transporting grain over a given route is estimated as a function of: 1) a mileage coefficient of grain for a specified rail cost territory (Minnesota is in Western), 2) miles within the specified rail cost territory, and 3) the average of the constant cost for grain for the territory where the grain originates and for the territory where the grain is destined. These constant costs are terminal costs. Covered hopper cars are the conveyors in this study with capacities varying from 118,000 lbs. to 195,000, depending on the kind of grain. Cost functions (Table 4) in cents per cwt. are given for single-car, single trip and 50-car, single trip rail shipments.

Table 4

Cost Functions for Single-Car, Single-Trip and 50-Car, Single-Trip Rail Shipments (cents per hundredweight)[a]

		Single-car		50-car	
Grain	Territory	Constant	Mileage coefficient	Constant	Mileage coefficient
Wheat, soybeans corn, and grain sorghum	Southern	4.4003	.033416	2.3148	.033155
	Official	6.4608	.039707	3.3987	.039396
	Western	5.6942	.034631	2.9955	.034360
	Mountain-Pacific	7.0305	.034396	3.6984	.034127
Barley	Southern	4.7170	.035274	2.4762	.034841
	Official	7.0429	.042100	3.6971	.041584
	Western	6.2092	.036544	3.2594	.036096
	Mountain-Pacific	7.7132	.036219	4.0489	.035775

Table 4. Continued

Grain	Territory	Single-car Constant	Single-car Mileage coefficient	50-car Constant	50-car Mileage coefficient
Oats	Southern	7.0696	.045348	3.7260	.043932
	Official	10.4141	.055204	5.5035	.053480
	Western	9.2472	.047225	4.8868	.045750
	Mountain-Pacific	11.2154	.046402	5.9270	.044953

[a] Data in this table are based on data in Table 1 in (8).

Source: Fedeler, Heady and Koo (8)

On-Branch Line Annual Maintenance Costs

In its light density line study, the U.S. Railway Association (11) provides estimates of on-branch line annual maintenance costs under two situations: 1) total rehabilitation of a branch line and maintaining the line at that standard for a 50-year period and 2) upgrading a line to meet Federal Railway Administration Class I requirements and maintaining the line at that standard for 50 years. The assumptions underlying the cost estimates for these two situations are carefully spelled out. The average annual maintenance costs per mile under total rehabilitation was estimated at $2,165 and under upgrading, $4,181.

Capital Costs per Mile to Upgrade to Specified Standards

As indicated above, the U.S. Railway Association (11) estimated capital costs of upgrading branch lines for two levels, total rehabilitation and upgrading to meet Federal Railway Administration Class I requirements.[1/] For the initial year, capital outlays were estimated at $154,614 per mile for total rehabilitation and $25,314 for upgrading. Taking these first year capital costs together with the average annual maintenance costs to retain each of the standards, this study calculates the total undiscounted and discounted (at 5%) 50-year costs for each of the upgraded situations. The total undiscounted and discounted 50-year costs are sufficiently lower for upgrading to favor it over total rehabilitation except perhaps where important new traffic potential exists for branch lines.

Total Average Costs

In their study, "An Economic Analysis of Alternative Grain Transportation Systems: A Case Study," Baumel et al (1) estimated the fully allocated

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1/ Total rehabilitation means:

Construct at a 30 m.p.h. standard.
Use 107 lb. welded relay rail.
Two-thirds of the ties replaced ($26 each for purchase and laying).
Machine time, other track materials and direct labor (excluding supervision) are included.
There is a demand for the removed rail for relaying.
Salvaged materials are removed, transported to market and sold.

Upgrading to FRA Class I means:

Replace 400 ties per mile which assumes the existence of 240 good ties per mile; Class I standards require 640 good ties per mile.
It costs $37 to purchase and insert each tie.
Ties have a 30-year life.
Weld 10 rail ends per mile per year; there are 32 "short" rail ends per mile.
Replace two broken rail lengths per year (costed at three-fourths of the price of new rail).

costs (cents/bu.) of shipping corn in box and hopper cars from Ft. Dodge, Iowa to selected markets by size of shipment (see Table 1). They also compare these costs with published rates. Fully allocated costs for single box car shipments are above published rates for all market destinations except Seattle. Fully allocated costs for single hopper car shipments, however, are lower than published rates for all market destinations except for Milwaukee and the Gulf. Fully allocated costs for shipments by hopper car in 3 to 10, 50, and 100-car shipments were estimated to be higher than published rates except for the 50-car shipment to Chicago. The study states that fully allocated costs are computed with an arbitrary allocation of fixed costs to units of traffic. Because such allocation must by necessity be arbitrary, the study considers fully allocated costs as meaningless as a basis for pricing rail services. The study suggests variable costs as a lower boundary for pricing decisions on rail services. However, over the long run, railroad firms must meet total costs.

Carroll's (3) fully allocated costs include, in addition to his variable costs detailed above, all other revenue required to cover the remaining 20% of freight operating expenses, rents, taxes and a return of 6% after federal income taxes on the remaining property. This amount, over and above variable costs, Carroll identified as constant costs, and were pro-rated on a ton and ton-mile basis over all revenue traffic. In short, fully allocated costs equal variable costs plus an allowance that approximates the weighted average contribution per net ton mile made by all rail traffic to constant costs. Constant costs are divided into terminal and line haul costs on a cents/cwt. and cents/cwt.-mile basis for travel from specified towns in Montana and North Dakota to Minneapolis. Cost information in this study is very detailed, and to reiterate, is for shipping grain in covered hopper cars. Rail Form A formula is basic in this study's cost calculations. Direct comparisons of Carroll's fully allocated costs with Baumel et al's is not possible since the former are on a cents/cwt. basis and the latter on a cents/bu. basis.

In its transcript of minutes of the public hearing concerning the extension of navigation on the Minnesota River above mile 14.7 the Corps of Engineers, Department of Army, St. Paul District (5) includes the Soo Line Railroad Company's 1968 annual report. Using the itemized expenses and the tons of revenue freight handled, the company calculated expenses per ton of revenue freight handled. Operating expenses (maintenance of way and structures, maintenance of equipment, traffic, transportation and general) per ton of revenue freight handled amounted to $3.27. Net equipment and joint facility rents, along with taxes other than federal income taxes, added $0.62 more and fixed charges together with contingent interest added $0.18 more for a total of $4.07. Again, the fully allocated unit costs are on a different basis from the previous studies cited; however, the expenses in this study could easily be converted to cents/cwt. for comparison with Carroll's (3) fully allocated unit costs.

The Farmers' Cooperative Service, USDA, (7) studied how 14 regional cooperatives might reduce transportation cost through a coordinated effort. The report shows what transport costs were at the time of the study and how these costs might be reduced through coordination. According to the report, the average cost per ton for transporting grain and fertilizer for the 14 cooperatives in 1970 was $9.81 by rail and $4.23 by barge between the Midwest and the Gulf area. Most of the cost comparisons in the report are made on a cost per ton-mile basis. The 1970 costs per ton-mile for the 14 cooperatives for shipments between Midwestern and Gulf states were 7.46 mills for

Table 5

Total Costs and Cost per Ton-Mile for Shipments Between Midwestern and Gulf States by 14 Cooperatives, 1970

Mode	Direction	Ton-miles	Costs	Cost per ton-mile
		Number	Dollars	Dollars
Rail	South	858,579,000	6,405,000	0.00746
Rail	North	896,150,000	9,078,000	0.01013
Barge	South	3,571,062,000	9,749,000	0.00273
Barge	North	713,506,000	2,483,000	0.00348 1/
Total or average		6,039,297,000	27,715,000	0.00458

1/ Includes trans-Gulf shipments. Excluding trans-Gulf shipments and costs to reflect only river barge shipments and costs resulted in a ton-mile cost of $0.00336 (3.36 mills).

Source: Farmers' Cooperative Service, USDA (7)

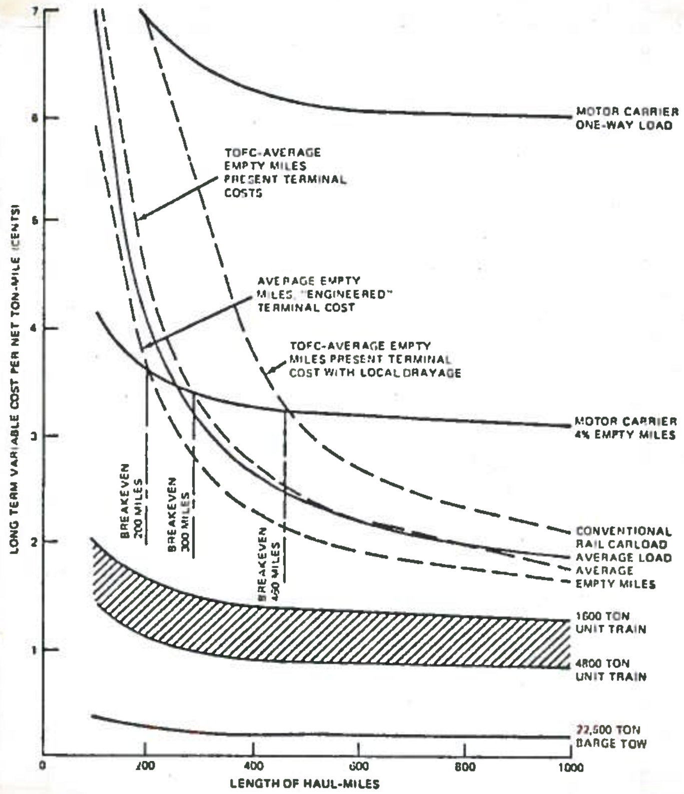
southbound rail transport and 10.13 mills for northbound. Rail rates or costs to shippers also varied because of the number of cars in the shipments, single car shipments carrying higher rates than multiple car shipments. The report also showed that rates for rail shipments that followed the river system were lower than those with origins and destinations considerable distances from the river system. Moreover, the report states that for the rail shipments observed in the study, costs for transporting fertilizer were higher than for grain because a smaller percentage of the fertilizer shipments had effective competition from barges. The report adds that railroads can reduce their own hauling costs through large volume movements and more effective use of equipment, and that the cooperatives may be able to share in such reductions through unit train movements. According to the report, unit train costs on a ton-mile basis can be about one half those incurred by operating a conventional train. Some ton-mile rates for unit train grain movements, 1971, reported in the study were 5.69 mills if the equipment were owned or leased by the receiver or shipper and from 7.25 mills to 8.09, if owned or leased by the railroad. The report cautions against comparing ton-mile costs of rail vs barge, particularly because distances between points differ.

Mosses and Lave (9) studied the ICC procedure for cost analysis embodied in Cost Formula A. This procedure was developed by the Association of American Railroads and the Canadian National Railway. They concluded that Cost Formula A has two large shortcomings: 1) it uses weights unrelated to modern transportation and 2) it is a procedure for deriving average rather than marginal costs. Volume 2 of 3 in Mosses and Lave contains a Ph.D. thesis, "Linehaul Process Functions for Rail and Inland Water Transportation" by J. S. DeSalvo. DeSalvo developed rail linehaul cost curves where costs per ton-mile are plotted against ton-miles per hour. These are short-run average cost curves for a freight train linehaul operation. Costs curves have been constructed for each of 12 levels of horsepower. The assumptions underlying these cost curves are: 1) a trip distance of 100 miles 2) gradient of terrain is zero 3) track curvature is zero 4) no delays in route 5) one six-axle engine 6) homogeneous 4-axle box cars, fully loaded 7) weight limited commodities 8) costs given by Equations 5.38, 5.42, 5.45, 5.47, 5,48, 5.49 and Table 5.6. In the analysis, as horsepower changes from 500 to 6000, the number of cars pulled increases from 10 to 200. Each of the cost curves can be considered a plant curve with horsepower as the fixed input and cars as the variable. The set of curves clearly shows scale economies within the range from zero to 196,000 ton-miles per hour -- a horsepower range up to 3000. In fact, scale economies continue to persist throughout the range of output considered, but a relatively small increments beyond 196,000 ton-miles per hour.

The U.S. Railway Association (10) compared the relative costs of trailer-on-flat-car and rail carload service, highway carriers, rail unit trains and barge transportation (Fig. 1). These costs are "engineered" full economic costs or estimates of true long-run costs, appropriately used for investment planning. These costs on a per ton-mile basis are graphed against length of haul in miles for these various modes of transportation. The 22,500 ton barge tow is shown to have lowest unit costs over the full

FIGURE 1

COMPARATIVE LINE-HAUL COSTS
FULL ECONOMIC COST BASIS



NOTES: 1. FULL ECONOMIC COSTS BASED ON PRESENT DAY EQUIPMENT REPLACEMENT COST, 10% CAPITAL COST, NO PROVISION FOR INCOME TAXES

2. NO ALLOWANCE FOR CIRCUITRY IN LENGTH OF HAUL

Source: U.S. Railway Association, "Prelim. System Plan" Vol. 1 (10)

length of haul of 1000 miles. Unit costs for unit trains of 1600 and 4800 ton capacities lie above barge costs but below other service modes over the full length of haul. Unit costs for motor carrier, 4% empty miles, break even with unit costs for trailer-on-flat-car, average empty miles, "engineered" terminal costs at 200 miles; with TOFC, average empty miles, present terminal costs at 300 miles; and with TOFC, average empty miles, present terminal costs with local drayage at 460 miles. Beyond those breakeven points, unit costs for TOFC are less than for motor carrier.

Capital Investments in Rolling Stock per Specified Levels of Capacity

Baumel and Wallize (2) in a study published in 1973 compared the annual costs of owning vs. leasing hopper cars. In arriving at the cost of owning, they assumed 8% interest and a 15-year equipment life in multiple car shipments. On a \$19,500 purchase price, annual depreciation, interest plus a 47¢/mile delivery cost less \$92 annual salvage value amounted to \$2221. The estimated average annual state taxes and administrative costs were \$320 and estimated maintenance costs at 1.25¢ per running mile ranged from \$692 to \$835 depending on percent in multiple car shipments.[2/] Estimated total annual costs of owning thus come to \$3233 and \$3375, compared with a leasing cost of \$200 to \$250 per month.

The Corps of Engineer's, Department of Army, St. Paul District (5) minutes from a public hearing published in 1969 contains testimony from Robert G. Gehrz, Soo Line Railroad Company. He testified that over the last 2 or 3 years Soo had invested in over 150 aluminum hopper cars at a cost of more than \$19,000 per car, a figure corresponding very closely to that quoted from Baumel and Wallize.

Rolling Stock Capacities by Type

Baumel and Wallize (2), commenting on the decline in railroad owned 40-foot box cars, stated that in 1960 the railroads had 560,000 but that when the study was made (publication 1973) the railroads had only 212,000. Baumel

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2/ 1.25¢/mile is for cars running from 50,000 to 60,000 miles per year.

and Wallize also noted sizes of covered hopper cars, which according to their observations vary from 2500 to 3500 cu. ft. when used in single car shipments to 4750 cu. ft. (jumbo hoppers) when used in multicar shipments.

The U.S. Railway Association (10) compared the cubic capacities of typical box cars and trailers, the former estimated at 5000 and the latter at 3060.

The Economics Research Service, USDA and the National Area Development Institute (6) prepared for the Committee on Agriculture and Forestry, U.S. Senate, a report under the title, "Prelude to Legislation to Solve the Growing Crisis in Rural Transportation" (published 1975). Pages 36-39 of this report are devoted to "Freight Car Capacity," which is very informative. Below are quotes from those pages:

> "... there are strong indications that capacity may be improved as readily by increasing car size and improving car utilization as by increasing numbers, at least for the grains."

> "Although the number of freight cars declined in recent years, average car size increased from about 55 tons in 1960 to more than 70 tons by 1973 (table 2.8). Cars installed in 1973 average 85 tons, compared with 62 tons for cars retired during the year (7, p. 53). The increased average car capacity has offset the declining number of cars so that total freight car capacity increased, especially toward the end of the last decade. The total 'freight' car capacity of Class I railroads was more than 96 'million' tons in 1972, up over 4 percent since 1960 (table 2.8). There was also a trend toward heavier loading as capacity increased. For example, the average carload increased from about 44 tons in 1960 to nearly 57 tons in 1973 (table 2.8). These standard measures of efficiency must be used cautiously. For example, average daily car mileage increased from about 46 miles in 1960 to nearly 58 miles in 1973 (table 2.8). However, the increase may, in part, have occurred because trucks took shorter haul freight traffic, including some agricultural commodities, from railroads. Also, competition with motor freight, which left railroads with longer hauls, may partly explain the tendency for freight cars turnaround time to increase in

in recent years."

"Caution should be exercised when using statistics on railcar numbers to judge the ability of railroads to move specific commodities. "Narrow-door boxcars" and "covered hopper cars" are used to transport grain, but many such cars also carry other classes of goods and are not available for grain. According to a spokesman for the Car Service Division of the Association of American Railroads, only about 30 percent of covered hopper car loadings are grain.

Ideally, when the objective is to measure carrying capacity, only railcars usually considered suitable for a particular use should be included. For grain movements, we considered only 40-foot narrow-door boxcars and railroad and privately-owned covered hopper cars (table 2.9). Even these cars are not all regularly used in hauling grain."

" TABLE 2.8.—AVERAGE FREIGHT CAR CAPACITY, TOTAL FREIGHT CAR CAPACITY, AVERAGE FREIGHT CARLOAD, AND AVERAGE DAILY CAR MILEAGE, 1960–73

Year	Average freight car capacity [1] (tons)	Total freight car capacity, class I [2] (1,000 tons)	Average freight carload [1] (tons)	Average daily car mile ge class I [2] (miles)
1960	55.4	91,947	44.4	45.7
1961	55.7	89,292	44.9	45.5
1962	56.3	87,224	45.4	47.6
1963	56.8	85,943	46.7	49.2
1964	58.3	86,771	47.8	50.0
1965	59.7	88,231	48.9	51.7
1966	61.4	91,441	50.1	53.0
1967	63.4	93,659	51.1	51.5
1968	64.3	93,549	51.8	53.5
1969	65.8	94,346	53.1	54.9
1970	67.1	95,556	54.9	54.6
1971	68.4	96,438	55.2	53.3
1972	69.6	96,079	56.3	56.1
1973 [3]	70.5	(4)	56.9	57.7

1 Association of American Railroads, "Yearbook of Railroad Facts," various years.
2 Interstate Commerce Commission, "Transport Statistics in the United States," various years.
3 Estimated.
4 Not available.

TABLE 2.9.—NARROW-DOOR BOXCARS AND COVERED HOPPER CARS BY OWNERSHIP, 1960-73

[In thousands]

Year [1]	40-ft narrow-door boxcars, railroad owned	Covered hopper cars		
		Railroad owned	Privately owned	Total
1960	438	64	9	73
1961	407	66	10	76
1962	380	69	11	80
1963	347	74	12	86
1964	311	82	15	96
1965	274	92	19	110
1966	247	105	24	129
1967	228	119	28	147
1968	202	123	30	153
1969	181	126	34	160
1970	[2] 207	131	39	170
1971	190	133	41	179
1972	173	142	44	186
1973	164	151	54	205
1974 [3]	155	154	60	214

1 Data for all years except 1974 were as reported for Jan. 1 of the following year—that is, 1960 was as reported for Jan. 1, 1961.
2 Increase due to reclassification of a number of 40-ft cars from wide-door to narrow-door category.
3 Aug. 15, 1974.

Note: The sum of individual items may not equal the total because of rounding.

Source: Car Service Division, Association of American Railroads. "

"Railroad-owned 40-foot narrow-door boxcars declined from about 438,000 in 1960 to about 155,000 in late summer 1974. Assuming a consistent 2,000-bushel capacity per car, total capacity would have been reduced from 876 million bushels to 310.4 million bushels -- a decrease of nearly 65 percent.

While 40-foot narrow-door boxcar numbers and their total capacity have declined, numbers of covered hopper cars and total capacity have increased dramatically. From 1960 to 1974, railroad-owned hopper cars increased from nearly 64,000 to nearly 154,000; capacity of such equipment increased from about 192 million bushels to 522 million bushels.3/"

"The downward trend in capacity of railroad-owned grain-type cars does not mean that the ability of the railroads to move grain has been impaired. Increases in the privately-owned covered hopper car fleet have helped to maintain capacity. For example, number of such private cars increased from less than 9,000 in 1960 to more than 60,000 in 1974, with an increase in capacity from 26 million bushels to 206 million bushels.

The combined capacity of all cars decreased from 1,094 million bushels in 1960 to 1,037 million bushels in late summer of 1974. Thus, the continuing shift from the traditional 2,000-bushel, 40-foot narrow-door boxcars to covered hopper cars that presently average an estimated 3,400 bushels has greatly reduced the number of cars needed to haul a given quantity of grain. Covered hopper cars now account for at least 70 percent of the capacity of all cars normally considered usable in hauling grain.

Besides increasing capacity per car, covered hoppers have also aided grain transportation in other ways. Covered hopper cars require no more time to load than a boxcar and can be unloaded more quickly and easily -- less than 8 minutes by gravity. Also, covered hopper cars are much less likely to become insect infested. Finally, because large covered hopper cars are more efficient in moving grain, rate reductions have resulted.

Although covered hopper cars have generally benefited the grain industry by increasing efficiency and reducing transportation costs, some shippers cannot use such equipment because spur lines serving their elevators are too light to handle the heavier weights. However, the net effect across the rail network has apparently been an ability to move more grain, as evidenced by the record tonnages of grain moved in 1972 and 1973.

Whether it is more economical to increase the capacity of the

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3/ Capacity figures for covered hopper cars are based on an assumed average carrying capacity of 3,000 bushels in 1960 and 3,400 bushels in late summer 1974.

railcar fleet or speed the flow of the present fleet has been thoroughly debated. Neither method is likely to solve the car shortage problem for agriculture and rural areas without either excess capacity or control mechanisms to force other sectors of the economy to share equipment during periods of peak rural demand. Currently, rail rates do not adjust to short-term changes in demand. Improved car use might result if lower rates were used to encourage shipment during "slack" periods. The pricing mechanisms would thus help allocate cars. Some research has been done, and some is now underway, on means for developing a pricing system capable of allocating freight cars to the most urgent demands. More study is needed, however."

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CHAPTER IV

COSTS AND CAPACITIES OF TRUCK TRANSPORTATION

Introduction to Truck Costs

To put the information situation before the early seventies into perspective a quote from Schnake and Franzmann, October 1973, is to the point. "Data on costs of hauling grain by truck are virtually nonexistent. A study by Cassavant and Nelsen for North Dakota revealed much information on grain trucking costs for that area: however, studies for other states or regions have not been made" (8, p. 8). In addition, the North Dakota study is based on 1966 data which is now almost ten years old. Trucking costs have changed much since the middle sixties particularly fuel costs.

A few studies have been completed since Schnake and Franzmann did their work. For example, Baumel and others (1) at Iowa State, November 1973, report on trucking costs in a six county area in Iowa. Easter and Nevins (3) at University of Minnesota report on costs of grain trucking in a four county region in Western Minnesota. Finally several studies on farm trucks were completed in Canada although they deal with trucks generally smaller than the commercial grain trucks.

This section focuses on those trucks which might be competitive with rail or barge in hauling bulk commodities. This limits consideration to the 810 bushel truck which handles most of the commercial movement of grain and other bulk commodities in Minnesota. Only passing reference will be made to the few cost studies that consider the cost of farm trucks with capacities from 100 to 450 bushels.

A Review of Truck Costs

A recent study of grain trucking costs in Minnesota Region 6E found that grain trucks are very competitive with rail up to about 80 miles from the Twin Cities. Beyond that point rail seemed to provide the best service and the lowest rate (3). Trucking costs were found to be sensitive to length of haul and level of utilization. Short hauls raised costs per cwt. mile, while higher utilization levels decreased costs per cwt. mile (see table 1). The study was based on late 1974 costs and synthetic analysis. Detailed data is also available on the variable and fixed costs (see tables 2, 3, and 4).

Baumel and others consider costs for three sizes of grain trucks: 810, 450 and 300 bushels. The costs are in bushel miles and are based on 1972 price levels in Iowa. Costs were estimated by a synthetic analysis of physical operations for different vehicles. The estimated operating cost of the 810 bushel tractor-trailer truck was .06 cents per bushel-mile (assuming four trips per day at 25 miles per trip and 55,000 miles per year). For long distance, 400 miles per round trip at 55 miles per hour and 110,000 mile utilization per year estimated operating costs were .037 cents per bushel-mile or 30 cents per running mile (1, p. 37).

Table 1. Rate per cwt. -mile vs. cost per cwt. -mile

Utilization level	Loaded trip distance+	Rate per cwt. -mile	Model I Cost per cwt. -mile	Model II Cost per cwt. -mile
60,000 mi	55	$ .0028	$ .00236	$ .00237
	75	.0022	.00221	.00222
	85	.0020	.00215	.00216
	95	.00189	.00212	.00213
	100	.0018	.00209	.00210
	105	.00181	.002093*	.002103
	115	.00174	.002072	.002082
	200	.0014	.001957	.001967
	300	.00127	.00192	.00193
80,000 mi	55	.0028	.00213	.00212
	75	.0022	.00198	.00197
	85	.0020	.00192	.00191
	95	.00189	.00189	.00188
	100	.0018	.00186	.00185
	105	.00181	.001863	.001853
	115	.00174	.001842	.001832
	200	.0014	.001727	.001717
	300	.00127	.00169	.00168
100,000 mi	55	.0028	.00199	.00197
	75	.0022	.00184	.00182
	85	.0020	.00178	.00176
	95	.00189	.00175	.00173
	100	.0018	.00172	.00170
	105	.00181	.001723	.001703
	115	.00174	.001702	.001682
	200	.0014	.001587	.001567
	300	.00127	.00155	.00153
120,000 mi	55	.0028	.00189	.00187
	75	.0022	.00174	.00172
	85	.0020	.00168	.00166
	95	.00189	.00165	.00163
	100	.0018	.00162	.00160
	105	.00181	.001623	.001603
	115	.00174	.001602	.001582
	200	.0014	.001487	.001467
	300	.00127	.00145	.00143

+ One-way loaded trip distance in miles.

* Rates per mile go up between 100 and 105 miles, causing driver compensation and cost to increase also.

Source: Easter and Nevins (3)

Table 2. Investment costs

Item	Model I	Model II
Building	$ 8,550.[b]	$ 34,200.[a]
Land	250.	1,000.
Office equipment	500.	2,500.
Shop equipment	1,016.50[d]	4,066.[c]
Pickup	2,250.	4,500.
Tractors[e]	64,480.	291,200.
Trailers	19,968. (22,464.)[f]	99,840. (112,320.)[f]
Total investment cost	$97,014.50 (99,510.50)	$437,306. (449,786.)

a/ $30,000 + (30,000 x .14) = $34,200; .14 is increase in the Wholesale Price Index (WPI) of building materials.

b/ One-fourth of $34,200., the building costs for a ten-truck firm, to estimate the building costs of the two-truck firm.

c/ $3,800 + (3,800 x .07) = $4,066.; .07 is increase in the WPI of mechanical equipment.

d/ One-fourth of $4,066., the shop equipment costs for the ten-truck firm, to estimate the shop equipment costs for the two-truck firm.

e/ Model I - $32,240.; each Model II - $29,120.; Model I costs per unit are higher because small firms are assumed to put more options on their equipment. These are not the list price, but what dealers thought they would actually sell for.

f/ Represents the cost of a hopper bottom trailer instead of a straight bottom trailer.

Source: Easter and Nevins (3)

Table 3. Fixed costs

Item		Model I		Model II
Capital cost		$ 4,918.83		$ 22,032.84
Depreciation		9,414.91		41,995.34
Office salaries		2,500.00		29,560.00
Licenses and permits		2,180.20		10,856.00
Taxes				
Highway use	444.00		2,220.00	
Real estate	283.80		1,135.20	
Social security	146.25		1,623.96	
Unemployment	205.70		1.060.80	
		1,079.75		6,039.96
Insurance				
Workmen's Compensation	159.75		1,888.88	
Health and medical	1,000.00		4,550.00	
Nonrevenue equipment	238.54		877.00	
Revenue equipment	3,160,00		15,800.00	
		4,558.29		23,115.88
General office expenses		2,540.00		11,400.00
Total fixed costs		$ 27,191.98		$ 145,000.02

Source: Easter and Nevins (3)

Table 4. Variable costs per unit

Item	Model I	Model II
	Cost/mile	Cost/mile
Fuel	$ .0993	$ .0993
Oil	.00165	.00165
Filters and gaskets	.00337	.00337
Grease	.00009	.00009
Batteries	.0004	.0004
Tires	.01055	.01055
Maintenance and repair	.03438	.02112
Driver compensation	.12607	.12607
Total variable cost	$ .27581	$ .26255

Source: Easter and Nevins (3)

The fuel costs alone have increased in the past year from $.27 per gallon to $.44 per gallon. Thus, even the Baumel study needs updating to current costs.

The Baumel study includes labor cost of loading and unloading waiting time as a separate item in the cost calculation. In the Easter-Nevins study it is not explicitly included, since the driver is not paid any extra for loading or unloading time. The Baumel study also considers only two alternative trip distances and utilization levels.

Case, 1974 (2), considers the cost of trucking four commodities; grain, coal, canned goods and steel. Although his data are very limited and only consider long hauls, they do provide information about commodities other than grain. However, the study does not specify key assumptions. For example, utilization and length of run are not clear. The costs are based on mid-1974 conditions and varying backhaul levels. In Table 5 below, the range of hauls is much too wide for specifying costs, since trucking costs vary considerably with the length of haul.

Table 5

Truck Costs (Cents Per Ton Mile)

	Empty Backhaul Levels					Range of Hauls
	0%	25%	50%	75%	100%	
Grain	--	2.4	--	3.4	--	200 - 1200
Coal	--	--	--	--	4.0	200 - 600
Canned Goods	2.2	--	3.3	--	--	200 - 1500
Steel	--	2.9	--	4.1	--	175 - 1050

Source: Case (2)

The information is "derived from knowledge of actual operations of owner operators and private truck operations, and do not represent the results of statistical average or sampling. The costs represent careful estimates of individuals knowledgeable of truck costs and operations " (2, p. 6).

Case also lists trucking costs in four appendix tables. These costs are for specific average lengths of run and utilization level for 1972. The costs are broken down by fuel, maintenance, tires, depreciation, licenses, taxes, insurance, overhead and driver costs. A comparison of the commodity transportation costs per vehicle mile indicates that steel is the most expensive, followed by canned goods, coal and grain (see table 6). The major reason for the high steel cost is high overhead costs, while canned goods show higher driver, financing and overhead costs. There is no indication why their costs are higher.

Table 6

Model Truck Costs 1972

	Grain	Coal	Canned Goods	Steel
Fuel (13¢)	$ 3,225	$ 3,478	$ 3,250	$ 3,000
Fuel Tax (11¢)	2,688	2,943	2,750	2,500
Maintenance	5,338	5,315	5,000	5,000
Tires	2,150	2,354	2,000	2,000
Depreciation				
Tractor	5,038	5,035	4,750	5,000
Trailer	1,008	1,108	1,000	1,000
License, Permits, etc.	1,500	1,500	1,500	1,500
Financing	1,000	1,025	2,500	1,000
Insurance	1,008	1,007	1,300	1,000
Driver	13,098	13,091	16,000	13,000
Driver Exp.	1,349	1,346	1,800	1,300
Overhead	934	932	1,800	10,000
Total Annual Cost	$38,336	$39,134	$44,450	$47,100
Average Length of Haul	800 miles	500 miles	800 miles	800 miles
Utilization	107,500 miles	107,000 miles	100,000 miles	100,000 miles
Cost per Vehicle Mile	$.357	$.366	$.444	$.471

Source: Case (2)

Fedeler and others (4), 1975, at Iowa State estimate grain shipping costs by five axle, tractor-semitrailer trucks as part of An Interregional Analysis of U.S. Domestic Grain Transportation. "Grain Trucking costs are developed for the Midwest and then the costs for the other territories are calculated by multiplying comparative territorial factors by the Midwestern costs " (4, p. 57). Trucking costs, based on the 1972 cost structures, are represented by the following equation:

$$TC = 1.6 \sum_{i=1}^{8} (C_v^h H + C_v^m M) \text{ di Fi} + 2/3\ C_v^h$$

TC = cost of shipping a truckload of grain for a particular route;

C_v^h = hourly costs of trucking costs allocated to time;

H = hours required for one-way trip;

C_v^m = mileage costs of trucking costs allocated to distance;

M = one-way mileage

di = percentage of total miles traveled in trucking cost region i;

Fi = regional cost factors.

For the upper midwest the formula reduces to;

$$TC = 1.6\ (C_v^h H + C_v^m M) + 2/3\ C_v^h.$$

The 1.6 coefficient means that 40 percent backhaul is assumed and that the backhaul covers all costs of the return trip. The 2/3 coefficient represents the truck costs of loading and unloading the combined time which is assumed to be 40 minutes per trip. Trucks are assumed to operate 3,000 hours and travel 110,000 miles annually for four years. The trucks cost $31,300 with resale value after four years of $8,900. The finance charge is 8 percent annual interest on funds invested in the truck. Annual state license fees, personal property taxes and other state fees or taxes, except fuel taxes, are estimated at $1,320. Federal taxes are $220 per year while insurance is $1,380. Overhead costs are $2,220 per year and drivers wages are $4.50 per hour. The total truck costs allocated to time are $8.70 per hour.

Trucks are assumed to average 40 mph on non-interstate highways and 60 mph on interstate highways. Forty-two percent of the first 300 miles is by interstate (4, p. 58-59). The costs per mile are $0.06945 for fuel and oil including taxes, $0.02668 for tires and maintenance and $0.01423 for repairs. The total cost allocated to distance are $0.11035 per mile (4, p. 59). The cost per ton of all grains except oats is calculated by dividing total cost by 24 tons. For oats the division is by 16 tons.

"All truck movements are combination with water, i.e., no grain is carried interregionally by truck alone. In reality, substantial quantities of grain are carried from one region to another by truck. The conclusion is reached that trucks haul longer distances because grain is hauled below cost such as for backhaul cargo,or trucks are available with a degree of timeliness which other modes cannot provide " (4, p. 178).

The U.S. Railway Association presents some trucking cost on a ton-mile basis However, these costs are not given in any detail and they do not indicate the basic assumptions such as utilization levels or year of data. For canned goods hauled 1,100 to 1,500 miles,truck costs are 2.4 cents per ton-mile with 25 percent empty backhauls. On steel hauled 900 to 1,050 miles the cost is 2.3 cents with 25 percent empty backhauls and 3.2 cents with 75 percent empty backhauls. (10, p. 119) These costs are lower than those reported by Case.

Several studies done in Canada present very detailed cost data on farm trucks (100 to 450 bushel trucks). The studies are based on surveys of actual truck costs for 1966-67 and 1971-72 (5, 6 and 9). The data are only of very limited use in estimating commercial trucking costs.

Finally, the Schnake and Franzmann study, although published in 1973, reports truck costs for 1966 (4). The costs are reported by large multi-state regions and by state. Again the data are of limited use due to the changes in relative prices over the past decade.

Highway and Road Construction and Maintenance Costs

Only three references report information on the costs of roads and highways. Baumel reports 1972 cost of resurfacing and maintenace for road surface and structures in cents per bushel per round trip mile (table 7). It is assumed that trucks are loaded with grain only one way. "The maintenance and resurfacing cost per truck-mile on the expected 1980 road system was computed by dividing the per mile cost of maintenance and resurfacing by the number of truck passes the pavement could handle before needing resurfacing " (1, p. 60).

The data for the cost calculation came from the Iowa State Highway Commission. The assumption underlying the cost determinations is that construction and maintenance costs for road surface and structures vary directly with the number of axle loadings of a certain magnitude that it sustains. All truck loads were expressed in terms of the equivalent 18,000 pound (18 kip) axle loading that the road would sustain through one pass by each truck. The equivalent 18 kip loadings and other factors used in the calculations were taken from tables developed by the American Association of State Highway Officials (AASHO) from the results of extensive road tests they conducted in 1960 and 1961 (1, p. 230).

Mohring calculates some rough 1973 cost figures for the interstate highway system. He estimated the capital outlays per route mile in rural areas at 739 thousand dollars and in urban areas at 2,787 thousand dollars (7, p. 16'

Table 7

Estimated Additional Highway Resurfacing and Maintenance Cost
in Cents per Bushel per Round Trip Mile, 1972

Pavement Type	810-Bushel Truck
Interstate Rigid	0.0006
Other Primary Rigid	0.0010
High Flexible	0.0030
Intermediate Flexible	0.0175
Surface Treated Flexible	0.2142
Secondary Unpaved	0.0056

Source: Baumel (1)

Total costs per vehicle-mile are estimated at 1.23 to 4.46 cents in rural areas and at 1.06 to 3.92 cents in urban areas (Table 8).

Finally, the U.S. Railway Association estimated highway cost figures associated with trucks for 1969 (10, p. 312). The calculations are based on work done for the U.S. Department of Transportation. In addition, they calculated the federal subsidy per vehicle mile traveled. The cost per mile for a 5-axle tractor per mile was estimated at 2.623 cents. The user charges paid per vehicle mile to the trust fund was estimated at 1.689 cents, which left at 0.934 cent subsidy per vehicle mile.

Truck and Highway Capacities

The only published reference currently available that considers Minnesota's capacities is the recent State Planning report on Grain Transportation in Minnesota (12). It points out several possible bottle necks in the current Minnesota road system. One is the spring road restrictions that affect grain movements about two months of the year. This tends to be most critical in Southern Minnesota because of its heavy reliance on grain trucks. Sixty to ninety percent of the grain shipped from Southern Minnesota elevators moves by truck (12, p. 61). Highway 169 from Mankato to the Twin Cities may be particularly over used, as shown by the increase in accidents.

A second possible bottle neck includes 70 bridges on the state trunk system that have legal load limits under 9 tons. Third, 2,700 county and township bridges have legal load limits under 9 tons. Finally, there are 5,000 miles of state trunk highway with pavement less than 24 feet wide.

Table 8

Interstate System Costs Per Vehicle-Mile, 1972-1973

Interest Rate (percent)	Cost Per Route-Mile			Total Cost Per Vehicle-Mile (in cents)
	Capital	Maintenance	Total	
Rural				
5	$ 36,950	$ 5,490[a]	$ 42,440	1.23
10	73,900		79,390	2.31
20	147,800		153,290	4.46
Urban				
5	139,850	15,010[b]	4,860	1.06
10	279,700		294,710	2.01
20	559,400		574,410	3.92
Total				
5	56,700	7,330[c]	64,030	1.14
10	113,400		120,730	2.15
20	226,800		234,130	4.18

a. Estimated annual maintenance cost per mile for a four-lane rural expressway.

b. Estimated annual maintenance cost per mile for an urban expressway with six or more lanes.

c. Weighted (by number of miles completed) averages of urban and rural figures.

Source: Mohring (7)

The majority are in agricultural areas.

The extent that the bridges, narrow roads and spring road restrictions limit truck travel is not clear. Much depends on how the limits are enforced. What is needed is a more detailed review of these bottle necks to determine their impact on commodity movements.

The work done by Todd in Minnesota region 6E is an example of some of the research needed (13). He determined how the road restrictions were applied and enforced in each county. To complete the picture he looked at the program each county had for upgrading the roads, including roads needing upgrading and the cost of upgrading.

The U.S. Senate report on rural transportation considered capacities for the states and the nation (11). Very gross figures are presented on the state rural road deficits and the cost of improving the total. Better and more complete data can probably be collected from the Minnesota State Highway Department.

The general conclusion of the Senate report was that "the rural road system is apparently sufficiently extensive to serve most rural areas in the country " (11, p. 41). In addition, they reported that "although there have been some recent delays in obtaining equipment and local shortages sometimes occur, trucking services to agricultural can generally be expanded to meet needs. ... Therefore, we would not expect long-term shortages of trucks" (11, p. 54). The study by Nevins and Easter in Western Minnesota tends to confirm these results for , at least, part of Minnesota (3).

A final source of possible restrictions on truck capacity is economic regulation and licensing, both in terms of operating areas and rates. Interstate carriers hauling grain are exempt and unrestricted as to operating areas or rates. The agricultural exemption allows competition between all carriers (even those who generally carry regulated commodities) since they are free from regulation when hauling exempt commodities (11, p. 57).

"It is difficult to measure the effect of regulation on rates and service. However, two commodity groups shifted between exempt and regulated status in the 1950's and may thus provide a clue. Poultry and frozen fruits and vegetables were declared exempt during the 1950's. Following the court actions, rates decreased and service reportedly improved......And after 1958, when frozen fruits and vegetables were again regulated, rates increased " (11, p. 58).

Even though grain trucking is exempt from interstate regulations, grain trucking within Minnesota is subject to licensing and minimum rates. The effect of this regulation is briefly discussed by Easter and Nevins (3). It is also mentioned in the State Planning Agency report (12).

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3. K. William Easter and Rolland J. Nevins, "The Cost of Grain Trucking in Minnesota Region 6E," Minnesota Agricultural Economist (Forthcoming in July issue).

4. J. A. Fedeler, Earl O. Heady and Won W. Koo, An Interregional Analysis of U.S. Domestic Grain Transportation, Iowa State University, 1975. CARD Report 54T.

5. S. N. Kulshreshtha, An Economic Analysis of Farm Truck Ownership, Utilization and Cost of Hauling Grain in Saskatchewan 1971-72, Aug. 1973. RR: 73-09 (Report to Central Office Grain Handling and Transportation System Rationalizations, Government of Saskatchewan), 270 p.

6. Surendra N. Kulshreshtha, Cost of Owning and Operating Farm Trucks for Grain Hauling in Saskatchewan (an Economic Analysis), July 1974. Tech. Bulletin BL: 74-09, Dept of Agricultural Economics, University of Saskatchewan, Saskatchewan, Canada, 60 p.

7. Herbert Mohring, "Three Back-of-an-Envelope Evaluations of the Interstate Highway System," Perpectives on Federal Transportation Policy, ed. by J. C. Miller III (1975, American Enterprise Institute for Public Policy Research, Washington D.C.) pp. 165-72.

8. L. D. Schnake and John R. Franzmann, Analysis of the Effects of Cost-of-Service Transportation Rates on the U.S. Grain Marketing System, USDA, ERS in cooperation with Oklahoma State University, T.B. #1484, Oct. 1973.

9. E. W. Tyrchniewicz, A. H. Butler and O. P. Tangri, The Cost of Transporting by Farm Truck, Research Report #8, Center for Transportation Studies, The University of Manitoba, Winnipeg, July 1971.

10. United States Railway Association, Preliminary System Plan, Vol. 1 (Railroads in the Northeast and Midwest Region), Feb. 1975.

11. U.S. Senate Committee on Agriculture and Forestry, Prelude to Legislation to Solve the Growing Crisis in Rural Transportation, U.S. GPO, Feb. 10, 1975.

12. Minnesota State Planning Agency, Grain Transportation in Minnesota, January 1975, 91 p.

13. Richard Todd, Current Policies for Vehicle Weight Restrictions on the Roads of Region 6E, Mimeograph, Dept. of Agricultural and Applied Economics, University of Minnesota, March 1975, 23 p.

Addendum - Chapter IV

A study for the Agricultural Research Service of the USDA stated:

> "Private and common motor carriers who were hauling grain as a means to avoid "deadhead" miles were interviewed. Their charges for hauling grain were remarkably consistent and approximated 48 cents a mile ($0.00072 per bushel-mile). These carriers, who were hauling grain strictly as a "last resort," admitted that the moves were not particularly lucrative but that "something was better than nothing." 1/

The rate of 48 cents a mile or $0.00072 per bushel-mile indicate a payload of 667 bushels (40,000 lbs) and is for backhauls in van trailers. A similar rate was indicated for backhauls on flatbeds with lift-off sidewalls. The survey was apparently taken in 1974 or early 1975. These rates are the equivalent of .0012 per hundredweight mile. This approximates the Minnesota minimum rate for grain hauled 300 miles or more in 1974. It is below the current Minnesota minimum rates and is less than the fully allocated one-way costs found by Easter and Nevins. However, these are backhaul rates.

1/ P. VII-6, Agricultural Research Service, USDA, Feasibility of Developing Containerized Transport and Storage System for Grains and Soybeans to Facilitate Use of Wide Range of Transport Vehicles prepared by A. T. Kearney, Inc., June 1975.

CHAPTER V

COSTS AND CAPACITIES OF PIPELINE TRANSPORTATION

Pipelines as a mode of transportation go back to 5000 B. C. when the ancient Chinese joined sections of bamboo together with pitch to bring water from hillside streams to villages and fields.[1/] Pipelines have been an important factor in U. S. transportation since 1865 when the first crude oil pipeline was constructed in Western Pennsylvania. This pipeline made it possible to transport crude at a cost considerably less than the price charged by teamsters and led to construction of other lines throughout the Appalachian oil fields.[2/]

Although the principles that govern pipeline operations are universal, there are really three categories of pipelines. First are the crude oil and petroleum products pipelines. These pipelines carry not only gasoline, diesel fuels and heating oils but also liquefied petroleum gases. The second type are natural gas pipelines. The third category are those that move a variety of products such as sulfur, liquid fertilizer and coal in slurry forms.[3/]

The following section is basically concerned with the first category of pipelines which are economically and practically competitors with water and rail for transportation services. (Approximately 42 percent of the nation's petroleum moves on the inland waterways, Great Lakes or oceans. Other modes offer little or no competition for pipelines for the transport of

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1/ Transportation: The Nation's Lifelines, George M. Harmon, ed., Industrial College of the Armed Forces, Washington, D. C., 1968, p. 49.
2/ D. Philip Locklin, Economics of Transportation, Homewood, Ill., Richard O. Irwin, 1972, p. 607.
3/ Transportation: The Nation's Pipelines, p. 49.

gas under low pressure.) The third category of pipelines is for practical purposes still a new technology, although there is one slurry pipeline (the Black Mesa Line) that has been in operation since 1971. It is capable of moving 5 million tons a year over its 273 mile length.[4/] A separate section discusses coal slurry costs and their potential impact on other modes.

Pipeline Cost Factors

Pipelines are similar to railroads in that they are very costly and their construction requires major capital investment. Once built they cannot be moved or easily altered. However, if located properly and designed in relation to expected throughput, pipelines are a very low cost and energy efficient mode of transportation.

The Project Independence Task Force Report (6) points out that pipelines (and refineries) which may have been optimally located for traditional sources may be poorly located for new oil sources such as Alaska or the Outer Continental Shelf. The reduction in dependence on oil from foreign sources sought by Project Independence may further disturb the historical pattern of oil flow. One result of new and more distant source locations is a need for new pipelines (or other transport or equipment) and/or shipping facilities disproportionate to the increase in oil consumption because the oil must be shipped greater distances. The development of shale oil or synthetic oil and gas at the mine head sites would also add to the need for new oil transport facilities.

4/ Transport of Energy Materials, Department of Transportation, November 1974, p. VII-3.

A pipeline has the high initial fixed costs associated with construction, obtaining right of way and purchasing pumping equipment (and has location inflexibility), therefore risks and uncertainty associated with the above factors may be sufficient to shift investment to oil transport equipment that is more flexible -- at least until origins and destinations are better defined.

The variables determining pipeline operating costs are throughput, line diameter, and pumping horsepower. Volume can be increased by increasing line diameter and/or pumping capacity as the power required to overcome the surface friction of the pipe decreases as the line diameter increases. This results in markedly increasing returns to scale, and consequent reductions in units costs of movement, with increases in line diameter (8). The concurrent requirement to take advantage of the increasing returns to scale is the ability of the market area to furnish sufficient demand for throughput at the optimum or near optimum rate.

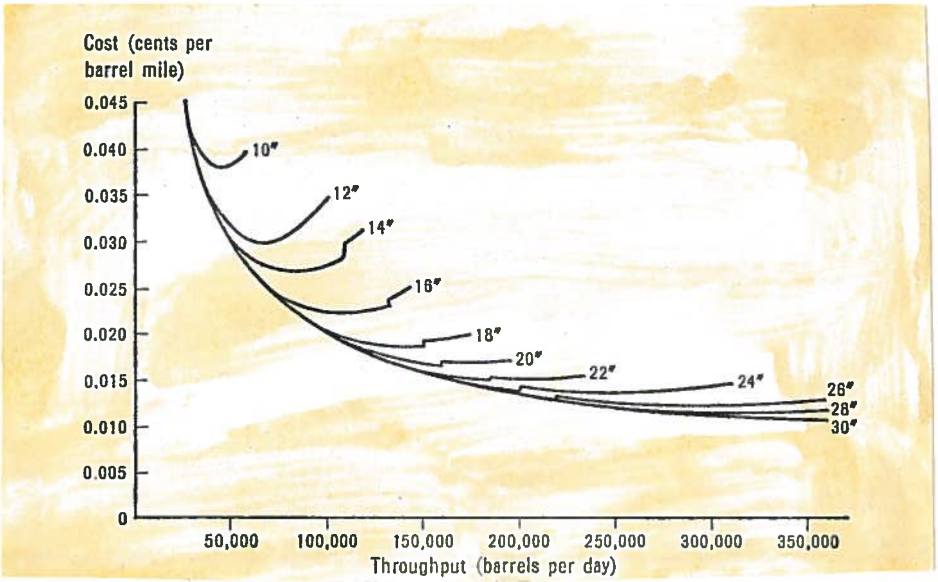
Meyer et. al. (4) provide a detailed analysis of these costs for various levels of throughput. Although outdated, figure 1 is included to illustrate the markedly increasing returns to scale that are possible. These 1952 costs decrease from 2.37 mills per ton/mile for 25,000 barrels per day through a 10 3/4 inch line to .513 mills per ton/mile for 400,000 barrels per day through a 30 inch line. These costs assume a level terrain and a pipeline length of over 175 miles.

Meyer et. al. (4) categorize costs as:

1. Those variable with line diameter including:

Figure 1

Average Costs of Operating Crude Oil Pipelines
by Throughput and Line Diameter



Source: Leslie Cookenboo, Jr., "Costs of Operating Crude Oil Pipelines," Rice Institute Bulletin, April 1954.

a. costs of laying the line

b. costs of steel, pipe coating, valves, etc.

c. depreciation (25 year life) interest, property tax on pipeline and maintenance costs.

2. Those variable with horsepower including:

a. electric power

b. labor used in operation and maintenance of pumping stations

c. interest, depreciation and property taxes on the investment in pumping stations.

3. Those costs variable with length of line including:

a. initial costs of tankage

b. surveying right of way

c. damages to the terrain

d. costs of maintenance and operation of a communications system.

These costs are essentially linear for lengths of line exceeding 175 miles.

Table 1 and Figure 2, although expressed in revenues - not costs - are indicative of the cost advantages of pipelines for the period 1962-72 (7).

Vol. II of the Project Independence Task Force Report (6) developed estimates of model pipeline costs (tariffs) between representative origin-destination pairs based on a simulation model that approximates the North American pipeline system. Although a recent study (1974) which used current data, it should be noted that the study was more interested in developing <u>relative</u> costs of pipelines between <u>alternative locations</u> than in developing

Table 1

Average Freight Revenue Per Ton-Mile, 1962-1972
(Cents)

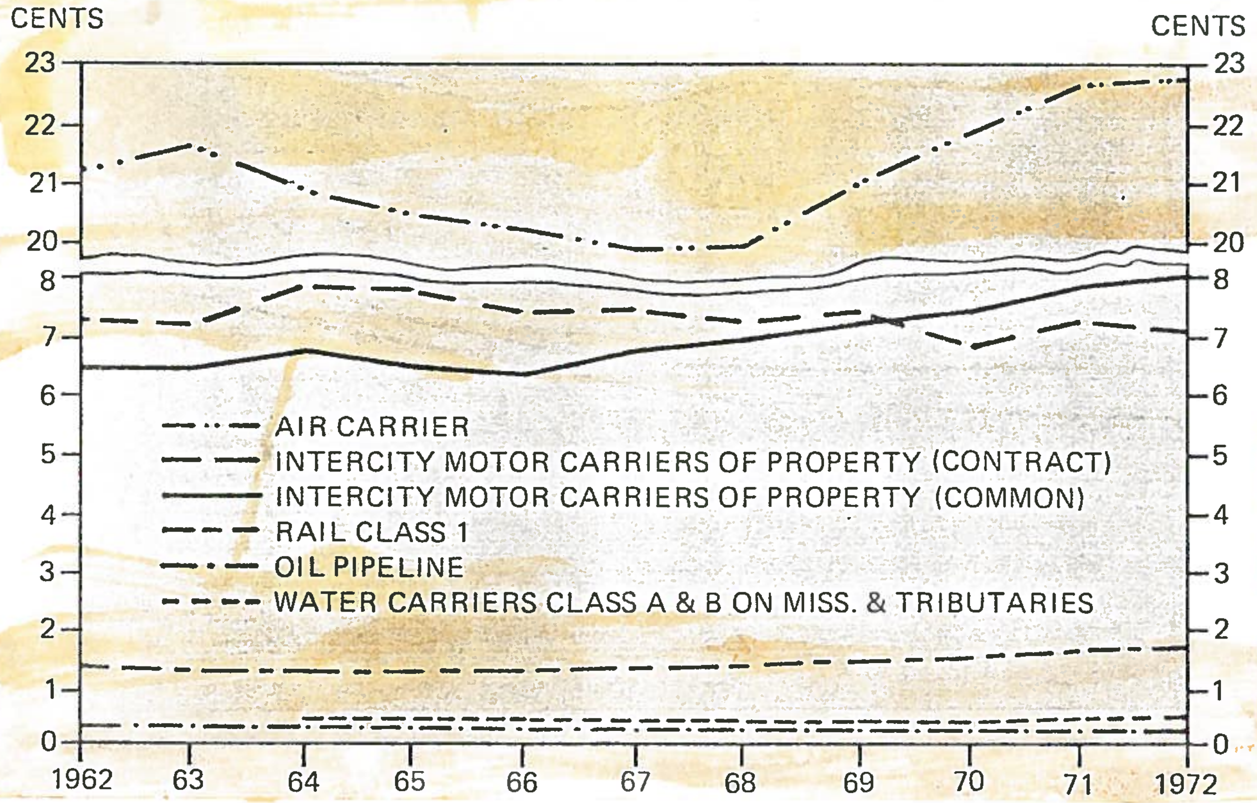
	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Air carrier certificated, domestic operations, scheduled service	21.31	21.72	20.97	20.46	20.21	19.90	19.97	21.03	21.91	22.61	22.75
Class I rail	1.35	1.31	1.28	1.27	1.26	1.27	1.31	1.35	1.43	1.59	1.62
Class I intercity motor carriers of property[1]											
Common	6.41	6.38	6.66	6.46	6.34	6.65	6.93	7.21	7.46	7.85	8.00
Contract	7.29	7.13	7.85	7.66	7.31	7.36	7.23	7.35	6.85	7.20	7.02
Oil pipelines	0.32	0.32	0.30	0.28	0.27	0.26	0.26	0.27	0.27	0.29	0.29
Class A and B water carriers	n/a	n/a	0.45	0.44	0.43	0.38	0.40	0.41	0.43	0.47	0.47

[1] Intercity service.

Source: Summary of National Transportation Statistics (7)

Figure 2

Average Freight Revenue Per Ton-Mile
1962-1972



Source: Summary of National Transportation Statistics (7) costs which can be compared to the costs of alternative modes!

The basic model and assumptions were:

"The tariff between any two points that are connected by pipeline is a function of the total investment in the pipeline segments connecting the two points. The tariffs computed in this manner will not equal the exact tariffs actually charged in most cases due to the number of independent pipeline firms and market circumstances, but they are very close in most cases and they accurately represent the relative costs of pipeline transportation from alternate origins.

The tariff or cost per unit throughput for any pipeline segment is estimated to be equal to the annual "cost of service" for the segment, divided by the annual flow. The "cost of service" is set equal to 20 percent of total investment. Thus, the tariff per barrel is set such that annual revenues will equal 20 percent of total investment. Note that this is not equivalent to a 20 percent rate of return on investment, since operating and other expenses have not been deducted from annual revenues.

Pipeline investment comprises three elements: the cost of steel (C_s), which is a function of pipe tonnage; the cost of construction (C_c) which is assumed to be proportional to the outer diameter of the pipe; and the cost of pumping capacity (C_p) which is a function of capacity, diameter, and temperature.

For oil pipelines, total investment, I, per mile is:

$$I = C_s + C_c + C_p$$

with

$$C_s = 28.2 \cdot A \cdot (D + t) \cdot t \qquad (1)$$

$$C_c = B \cdot (D + 2t) \qquad (2)$$

$$C_p = \frac{23.63 \cdot S \cdot Q^{2.75} \cdot V^{0.25}}{D^{4.75}} \qquad (3)$$

where

Q = Capacity in thousands of barrels per day
D = Internal diameter of the line in inches
t = Pipe wall thickness in inches
V = Average oil viscosity in centistokes
A = dollars per ton of steel - varies by geographic region
B = dollars per inch diameter per mile - varies with the difficulty of the terrain crossed
S = dollars per horsepower

> The description of each segment presented in the data base consists of its starting point, its ending point and its initial capacity. The starting and ending points determine its route and hence the type of terrain and climate through which it passes. Cost factors for the acquisition and laying of pipe are derived from regional data stored in the data base. Pipeline flowing temperature follows from a similar source; it is needed in the computation of investment as a function of throughput. The length of the pipeline segment is computed using the formulae of spherical geometry to determine the great circle distance from beginning to ending points."

The FEA Project Independence Report (6) also contains a model for determining pipeline investment requirements which includes construction cost parameters which vary by region and terrain.

Pipeline Capacity

Although the throughput of any given pipeline can be measured and is known, the pipeline capacity of an area or region is more difficult to define. There are really three separate pipeline networks covering the U.S. (and Canada). The three networks include one for crude petroleum, one for petroleum products and one for natural gas. Each network is highly interconnected and has many branch lines. Some lines are reversible, although this is the exception rather than the rule, as reversibility requires additional investment in valves, pumping stations, etc.

Capacity of a given line depends on its diameter, pumping pressure (within the structural limits of the line), and physical characteristics of the fluid. Capacity into an area at any given time depends on the particular system configuration at that time, i.e., connections, branch discharges, and product characteristics.

Minnesota Facilities

Minnesota has a limited number of crude oil and petroleum products pipelines. The total mileage is about 2671 miles, about half of which are for crude oil. (The natural gas pipeline system is not considered in this paper.) The total capacity of the crude pipeline system in 1970 was about 2.4 million barrels per day. Products pipeline capacity was about 400,000 barrels per day (10). However, to be able to use the capacity requires both that supplies of crude or products be available at the source of the pipeline and that other locations on the pipeline or connecting branch lines do not withdraw the crude or products before it reaches its Minnesota destination or, in the case of crude, is not sent on through Minnesota to a more eastern destination. According to Walton (9), the maximum amount of crude delivered to Minnesota was about 150,000 barrels per day.

Refineries

There are three refineries in Minnesota which reportedly receive 75% or more of their crude oil from Canada. In addition, a fourth refinery in Superior, Wisconsin gets 90% or more of its crude from Canada. These refineries are:

a. Continental Oil Co. at Wrenshall with 18,500 barrels per day capacity.

b. Ashland-Northwestern at St. Paul Park with 60,000 barrels per day capacity.

c. Koch at Pine Bend with 100,000 barrels per day capacity.

d. Murphy at Superior, Wisconsin with 36,500 barrels per day capacity.

These 1973 capacities were obtained from (1). The total of 178,500 bbls. per day for the three Minnesota refineries was increased in 1974 to 196,490 (10). Historically, these refineries have received virtually all of their crude oil by pipeline.

Crude Oil Pipelines

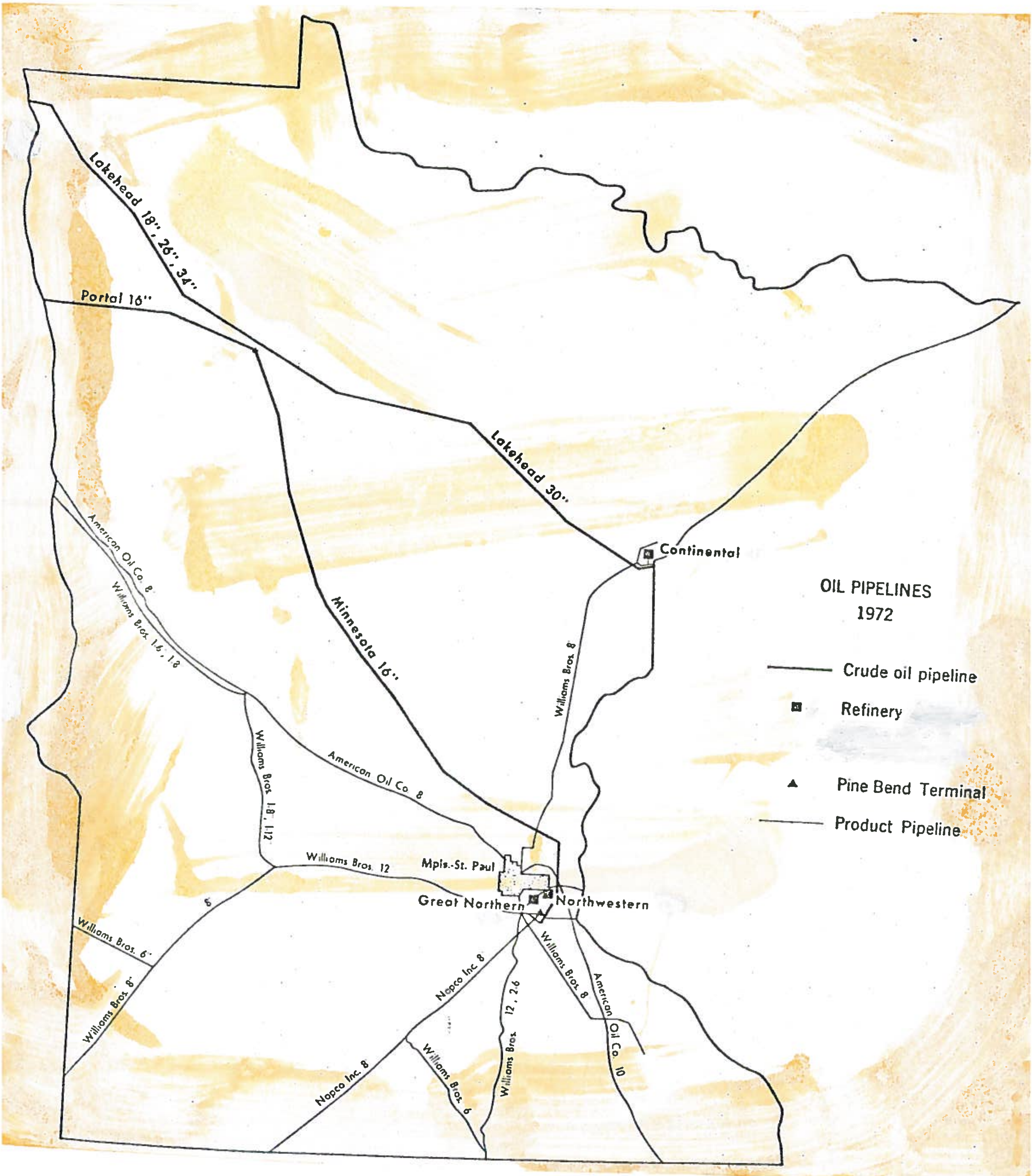
Figure 3 shows the location of pipelines in Minnesota. Note that there are no crude oil pipelines coming into the state from the South, i.e. the Gulf area. There are two crude pipelines entering the state from the North, i.e. the Lakehead pipeline and the Portal 16 inch pipeline. A crude pipeline which lies wholly within the state (the Minnesota Pipeline -- 16 inch) runs from Clearwater to the Twin Cities (Pine Bend). The latter, naturally, services the two Twin Cities refineries, but 75% or more of the crude oil originates in Canada and enters the U.S. via the Lakehead pipeline.[5/]

The Oil and Gas Journal has published maps of the North American pipeline system (1). The Lakehead pipeline connects the two portions of the Canadian Interprovincial Pipeline.

The Interprovincial Lakehead pipeline illustrates the difficulty of defining capacity discussed earlier. After the junction with the Minnesota Pipeline at Clearwater, it proceeds through Minnesota to Superior, Wisconsin. It is the sole pipeline source for the 18.5 BBL Continental Refinery at Wrenshaw and the 36.5 BBL Murphy Refinery in Superior, Wisconsin. The Lakehead pipeline splits at Superior, with the South line (34 inch) going southeast across Wisconsin to the Chicago area. (There are no other

5/ Minneapolis Star-Tribune, April 27, 1975, p. 13C.

Figure 3



Source: American Petroleum Institute

refineries in Wisconsin.) It then proceeds as a 30 inch line northeast across Michigan, where it rejoins the North line at Sarnia near the Canadian Border, where it proceeds as the Interprovincial pipeline (2 – 20 inch). The North branch (30 inches) proceeds across Upper Michigan (where there are no refineries), crossing to lower Michigan near Mackinaw City and then rejoins the South branch at Sarnia, where it continues to Eastern Canada. Although the existing Interprovincial pipeline east of Sarnia is relatively small and supplies few refineries, the Canadian National Energy Board has authorized the construction of a new 300,000 plus barrel a day pipeline from Sarnia to Montreal for the purpose of supplying Eastern Canada with oil from Western Canada.[6/] Canada has announced its intention to phase out oil exports by 1983.[7/] In the interim, each year reduced amounts will be allocated to users. Consequently, although on a major pipeline route, Minnesota may be in the position of having virtually no "crude oil pipeline capacity" if its Canadian supplies are eliminated.

Various alternatives have been proposed to allow Minnesota to continue to utilize this pipeline. One, which is considered to be the cheapest and most workable, is the Chicago option, where U.S. Gulf Coast (or imported) oil would be pumped into the South branch of the Lakehead pipe at Chicago and be pumped east for consumption in eastern Canada. Under this proposal, crude from Western Canada would then be available in Minnesota from the west portion of the Lakehead pipeline.

6/ Wall Street Journal, May 21, 1975.
7/ Minneapolis Star-Tribune, Op. cit.

Another proposal would involve building new pumping stations to reverse the flow of the Canadian Transmountain pipeline. Under this proposal, Alaskan oil would be pumped from Seattle overland to the Lakehead Interprovincial line for use in Minnesota.[8/]

If one of these alternatives does not become a reality, it will be necessary that large quantities of crude oil be brought to the Minnesota refineries, either via a new pipeline or by a competing transport mode. Because of the uncertainty of future sources of supply and construction leadtimes, it is unlikely that new pipeline capacity would be available for several years. Although barge transportation would not be available in the winter, it is highly likely that at least the Twin Cities refineries will be supplied during the shipping season by barge. This will be a major change, as crude oil historically has not been shipped by water to the Twin Cities. To operate the two Twin Cities refineries at 100% capacity would take the equivalent of 12 barges every day.

Product Pipelines

About one half of the 2671 miles of petroleum pipelines are products pipelines. These pipelines have the capacity to supply about one half of Minnesota's petroleum product requirements. Figure 3 shows the locations of the product pipelines. These pipelines had a combined capacity in 1970 of 401,000 bbls. per day (10).

8/ Minneapolis Star, May 6, 1975, p. 1.

Coal Slurries

Wilbur Smith and Associates (2) report estimates that 91 percent of the 1.12 billion tons shipped by pipeline in 1970 consisted of crude and refined petroleum products and their derivatives. (Gas pipelines were not included.) The remaining products are not identified as to industry origin but presumably include materials such as liquid fertilizer and sulphur. The only significant coal slurry pipeline operating in 1970 was the 273 mile Black Mesa Pipeline in Arizona which was reported to have transported about 2 million tons annually.

The only other coal slurry experience in the U.S. was the 108 mile long 10 inch pipeline between a mine at Cadiz, Ohio and a powerplant at Cleveland which operated from 1957 to 1963. Meyer et. al. (4) report that the construction cost was $65,000 per mile or $7,020,000. In addition, a processing plant costing from $1,500,000 to 3,000,000 was required for deliquefying and restoring the coal. The pipeline operating cost was liberally estimated at $1.20 per ton or 1.11 cents per ton/mile and the cost of processing the coal at 30 cents per ton. At that time, the total cost of $1.50 per ton was substantially less than the comparable rail rate even after a one-third competitive rate reduction. However, this pipeline was closed down after 6 years of operation when the railroad serving the area instituted a unit train and reduced the rate on coal from $3.22 to $1.88 per ton (8).

Current thinking about coal slurries might best be summed up by the following quotation from Vol. I of the Project Independence Report (6):

> "Coal movement by slurry pipeline is a new and developing mode which can offer lower costs than rail or waterway movement under proper conditions. Only one slurry pipeline is now in operation which handles about five million tons a year; lines now proposed or

> under consideration could total up to 100 million tons a year capacity. For all the slurry pipelines under consideration, water is needed at the rate of roughly 250 gallons per ton of coal moved. The availability of water, physically and legally, is a limiting factor in movement by this mode in more arid western regions. Ownership and operation is in the private sector without significant regulation. Because private slurry pipeline has no power of eminent domain, the acquiring of right-of-way is a major problem."

Slurry Costs

Slurry pipelines transport solid materials in a water medium. The basic principle of operation is that turbulent flow in a pipe will keep solid particles in suspension provided the particle size is small enough, the flow velocity is high enough and the particle concentration is not too great. To maintain the practical operating velocity of betweeen 3 to 6 feet per second, pumping stations are required from 40 to 80 miles apart, depending on the terrain. Pipelines normally have little overload capability above their rated capacity, but coal slurry lines can be run satisfactorily down to 60 percent of rated capacity.

The Project Independence Report contained the following analysis of coal pipeline economics:

> "Much of the capital cost of pipeline is independent of the capacity of the line. Cost of securing right-of-way, surveying, grading, etc., is independent of the size pipe to be laid. The steel required increases as the square root of capacity and labor costs increase roughly at the same rate. As a result, the investment needed per annual ton capacity goes down as capacity goes up. Normal practice appears to be to depreciate pipeline investment over 30 years and to ask a return on investment of 15 percent. About 70 percent of the transport tariff goes for depreciation and return on investment. Another 15 percent goes for pumping energy and the remainder for all other operating expenses.
>
> With the tariff strongly composed of fixed cost and a considerable portion of the fixed cost being independent of capacity, the tariff

curves exhibit a characteristic hyperbolic shape with capacity. Also, since the preparation and dewatering plants as well as some corporate costs are independent of distance, tariff should also be hyperbolic with distance. Figure II-B-5 is a 1974 computation by Bechtel, Inc., including expected corporate costs and return on investment as well as depreciation and operation. If rail tariff is in the range of 8 to 10 mils per ton mile, it is apparent that slurry pipeline becomes competitive with rail at roughly 10 million tons per year capacity and 500 miles distance. If waterway tariff is in the 4 to 6 mil range, the pipeline needs to carry in the neighborhood of 20 million tons a year for 1,000 miles to compete."

(Figure 4 is a reproduction of Figure II-B-5.)

To put things in perspective, the major facility proposed for Pigs Eye would handle 7.5 million tons per year. Estimated rail tariff for unit trains are $4.50 to $5.00 per ton. It would appear then that the original volume and rates proposed for the Pigs Eye terminal would have been substantially below the volume required for a coal slurry from North Dakota to the Twin Cities to break even.

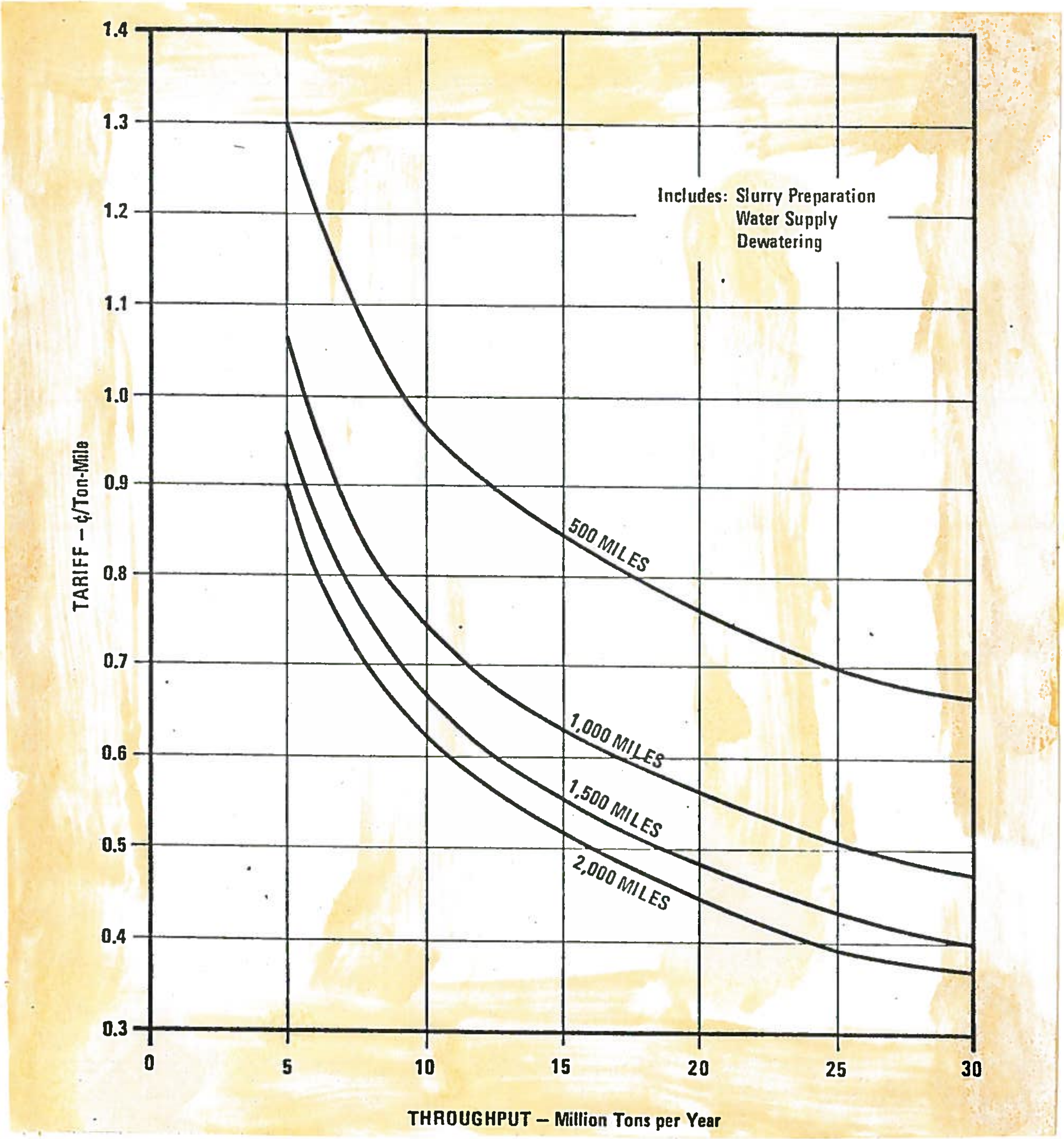
To further quote from the Project Independence Report:

"Tariff comparisons based on general rate curves are crude indicators of competitiveness at best. Actual rates will depend on the exact location of mine and plant, on the terrain and circuitry of the route, the cost of water, the laws of the States involved, etc. Meaningful comparisons can be made only on a case by case basis with the level of detail which, in fact, will be made by any real prospective operator.

It is instructive, however, to note that a slurry pipeline, as a new mode, encounters serious problems in getting started if a competing mode offers more or less direct service and has excess capacity. The tonnages involved for slurry pipelines are really quite large. Ten million tons a year, or 27,500 tons a day, is roughly the equivalent of four unit trains a day. Twenty-five million tons is larger than the total expected annual production of some coal districts. Slurry pipeline can be branched at the head and tail end to take the production of more than a single mine and to feed several plants; however, the price advantages melt with excessive mileage through lower capacity line. In general, the decision to start a slurry pipeline requires the firm commitment of a large fraction of a district coal production to supply

Figure 4

Coal Slurry Pipeline
Transportation Costs



Source: Project Independence Report

several major regional power plants or synthetic plants.

As an example, a 1,000 mile, 25 million ton line could deliver coal at .51¢ per ton mile based on figure II-B-5 and of that, approximately 70 percent, or .35¢ per ton mile would be fixed capital costs. If, however, the expected supply or demand did not develop, the line could physically run at 60 percent capacity. The capital cost would remain the same but, spread over only 60 percent of the ton miles, the rate for capital cost alone would rise to .58¢. Assuming that the operating cost would remain the same per ton mile, the total cost would rise to 147 percent of the full capacity tariff or .75¢ per ton mile. If the operator charges the higher rates, he loses much of his competitive advantage; if not he loses money. The financial flexibility to operate below capacity may be more restrictive than the physical limits.

At present, slurry pipeline do not have the right of eminent domain so that negotiations for land use along the route can be extended, expensive and not assured of success. The pipeline has, however, considerable flexibility in route and can jog around strongly contested plots. A railroad right-of-way across the proposed pipeline route raises a far more serious negotiation problem. A Bill now before Congress (Title IV-Amendment to S-2652) proposes to extend the right of eminent domain to slurry pipeline."

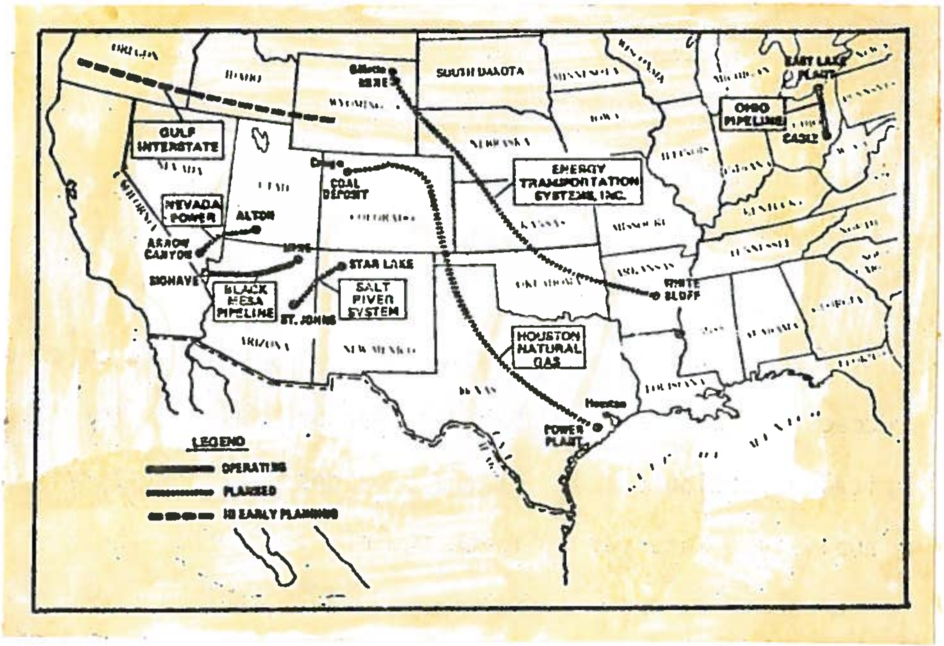
Figure 5 indicates the seven existing or proposed coal slurry pipelines.

These are:

1. The discontinued 108 mile, 10 inch Ohio capacity which had a capacity of 1.3 million tons per year.
2. The 18 inch, 273 mile Black Mesa Pipeline capable of moving 5 million tons per year.
3. The 175 mile Nevada Power Pipeline with a capacity of 10 million tons per year.
4. The Salt River System line which is estimated to be about 200 miles with a capacity of less than 10 million tons per year.
5. The 38 inch, 1038 mile Energy Transportation Systems line with a capacity of 25 million tons per year.

Figure 5

Proposed and Existing Coal Slurry Pipelines



Source: Project Independence Report

6. The 1,100 mile Houston Natural Gas Line with an assumed capacity of 20 to 25 million tons per year.
7. The 800 mile Gulf Interstate Pipeline from Wyoming to Oregon.

By analyzing the underlying condition of these 7 lines, the Project Independence Task Force (6) concluded the following about the future locations and conditions where coal pipelines will be competitive:

1. The Ohio pipeline had the disadvantage of being in the East, of being too short and had too little capacity.
   a. Size and length are necessary to compete costwise if there is an existing network.
   b. Eastern coal production is characterized by large numbers of relatively small mines with diverse ownership. The requirement of 10 million or more tons of coal per year is much easier to obtain from a large single-owner Western surface mine.
   c. In addition, Eastern coal generally has a low moisture content and can be ground and then burned by powerplants as shipped by rail without the expense of dewatering content. Plants using Western coal typically incorporate pre-drying so that some of the dewatering needed to burn slurry coal already exists in a plant designed for Western coal.
   d. One advantage of an Eastern location is that water is generally more plentiful. The scarcity of water (250 gallons per ton of coal) plagues Western coal slurry proposals.

2. Long distance coal slurry pipelines appear to be lower cost than rail, particularly at capacities of 20 to 25 million tons per year. Present unit train rail rates are in the .8 to 1.0 cents per ton-mile range, while the pipeline offers rates of .5 to .7 cents per ton-mile. A new long distance pipeline can also offer less circuitry than existing railroads. However, while such a route offers a significantly more direct pipeline movement, the problem of right-of-way for slurry pipeline is acerbated by the number of railroad rights-of-way the route crosses. Without the power of eminent domain, coal slurry is unable to cross competing rail lines.
3. The three shorter coal slurry projects would seem to be too short and too low in capacity to compete with rail <u>except</u> for the fact that in each case rail connection would require between 50 and 100 miles of <u>new rail</u> construction over rough terrain. Pipelines can compete with rail on the basis of investment costs for new construction.
   a. Route acquisition and preparation should be more expensive for rail than pipeline because the rail right-of-way is wider and has more stringent grade and turning radius restrictions.
   b. Pipelines right-of-way can generally be returned to grazing or agricultural use, while rail retains the use of the surface.
   c. Bridges and road crossings are simpler and less expensive for pipelines, and as the terrain becomes rougher, rail routes become more circuitous with an increasing cost advantage for

pipelines.

4. None of the seven pipelines is in a location where direct waterway competition is present. A long high volume pipeline could offer rates of 4 to 5 mills per ton-mile. However, it appears doubtful that a pipeline could offer rates more favorable than those negotiated in a long term, high volume barge contract since the investment required for expansion of waterway coal volume is limited to port facilities, barges and towboats. This investment should always be less than pipeline construction. However, if Federal policy regarding free use of the waterways is modified, then the comparison between waterways and slurries should be re-examined.

Conclusions on Coal Pipelines

- Coal pipelines cannot compete with waterways as long as capacity is adequate and costs of waterway improvements are borne by the Federal government.
- Short, moderate volume slurry pipelines are not likely to be price competitive with rail in cases where railroads already exist.
- Short, moderate volume slurry pipelines can be price competitive with rail where significant new rail route construction is required.
- Coal slurry pipeline is likely to be price competitive with rail in Western locations where new rail route construction would be required in rough terrain.
- Long, high volume coal slurry pipelines can be price competitive

with existing rail service.

- Steel requirements for coal slurry pipeline are equal to or less than those for railroad rolling stock and track in most circumstances.

Summary and Conclusions

Under proper conditions, pipelines are a very cost effective mode of transportation. In addition to crude petroleum, refined petroleum products and natural gas, there are numerous other commodities, both liquid and solid, that can be transported by pipelines. As the technology is perfected, more of these commodities, such as coal, will be moved by pipelines. However, with very few exceptions, only crude oil, natural gas and petroleum products can compete effectively with barge transportation,[9/] for the following reasons:

1. Economies of scale are very important in pipeline economics. To achieve per unit costs lower than competing modes, very large quantities must be available for point-to-point movements. If the volume is not available from a single source or not destined to a single destination, additional costs of collection and/or distribution will be incurred.

2. Pipelines have high initial costs. Because they are a long-term investment, pipelines will not be built to transport commodities for which there are no firm projections of demand (as well as available supplies), i.e., pipelines will not be built to meet one-time demands or demands of uncertain

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9/ One of the exceptions may be liquid fertilizer. Cost data for piping liquid fertilizer were not analyzed.

duration.

3. Pipeline transportation of solids, i.e. coal, sulfur, grain, etc., has a disadvantage in that they incur costs in preparation for shipment and in drying or conditioning, which are not incurred in other modes. These are frequently added steps (costs) which do not contribute to the product's usefulness. In addition to the added handling costs, pipeline transport of solids requires large quantities of water. Water might very well be a scarce resource in the origin area, but, in any event, moving the extra weight needed for the emulsion requires energy and adds to costs. This is in contrast to the movement of liquids, such as petroleum products, which do not require extensive preparation and do not have the added weight of water to pump.

Because of the factors of economies of scale, high initial costs and the costs associated with liquefaction, it is not expected that pipelines will be constructed to compete for solid commodities currently barged on the Upper Mississippi. These include grain, coal, and other minerals, including solid fertilizer.

The outlook for crude petroleum and petroleum products is distinctly different. Pipelines can compete economically for large volume shipments of these commodities and, over the long-run, will be their dominant mode of transport. However, until the uncertainty about the total energy picture is resolved, water transportation of petroleum on the Upper Mississippi will probably increase. The products pipeline from the South is operating at capacity, and the crude oil supply from Canada is being reduced. In the short-run, the most economical way to get needed additional supplies to the Upper Mississippi Valley will be by barge. The uncertainty of the amount and location of future sources of supply precludes investment in pipelines. However, once the questions pertaining to future types and share of energy (i. e., coal, oil, nuclear) in the area are resolved and the question of long-term supplies of oil in the Upper Mississippi area is resolved, it appears likely that pipelines will be constructed that will reclaim the petroleum movement.

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CHAPTER VI

TERMINAL, HANDLING AND COMPLIMENTARY COSTS AND CAPACITIES

TERMINAL COSTS

Some idea of the importance of handling costs to the overall transportation bill can be deduced from the results of an Iowa State University study. "Grain elevator costs of loading and unloading grain average approximately 20 percent of the estimated interregional grain transportation costs. Consequently, such costs are an important part of the total grain distribution costs and they should be included in grain marketing decisions." (3, p. 9) Therefore, if we want to examine the competitiveness of alternative modes of transportation or of intermodal transportation, we must include the handling costs associated with the various modes.

The cost figures involved in the handling function will not correspond directly to the cost figures associated with the various modes. "... shipping costs depend on the distance and quantity hauled, but handling costs depend only on the quantity." (3, p. 108) Thus, terms like cost per mile or costs per ton mile lose meaning in calculating handling costs. Handling costs will be associated with distance considerations only where a particular handling method might add to or reduce the overall transportation bill.

GRAIN HANDLING

In terms of volume, the major commodity group shipped by barge within the St. Paul District is grain. It is therefore important to examine the grain marketing system in the upper Great Plains and determine how handling costs within that system affect the competitiveness of waterborne transportation.

There is no definitive study which gives the costs of handling grain. Most recent studies which assign costs to these functions allude to one of two USDA, Economic Research Service reports:

ERS-501 Cost of Storing and Handling Grain in Commercial Elevators, 1970-71 and Projections for 1972-73.

ERS-513 Cost of Storing and Handling Grain and Controlling Dust in Commercial Elevators, 1971-72... Projections for 1973-74.

These studies developed average standardized book costs and average replacement costs for handling and storing grain. These costs are divided according to: area, type of facility (country, inland terminal, port), component (receiving, loading out, storage), and mode (truck, rail, barge).

ERS-501 is based on a survey of 251 grain elevators involving personal interviews of elevator personnel and analysis of company books. (9) Cost accounting techniques were used to allocate costs according to function. The study includes a breakdown of costs into fixed and variable components according to type of facility. This part of the study does not include a regional analysis; that information is included on computer files with ERS.

This study seems to give us a good idea of the average, per bushel, costs of handling the 1970-71 grain crop.

ERS-513 was an attempt to update the previous study and contains basically the same type of information. For this report surveys were sent to the 251 firms involved in the ERS-501 study. (10) The report is based upon information from the 175 firms that replied. Both studies suggest that there are cost differentials by mode, region, and type of facility.

This study gives average cost information based on actual company records for the 1971-72 fiscal year. The report goes on to use indices to project costs into the 1973-74 year.

From ERS-513 we can probably get as good a picture as possible of the average per bushel handling costs relative to the area involved in our study, for the 1971-72 crop year. But we are now in 1975, and we do not appear to have any more recent studies of this type. In using this information to interpret present or future time periods, a great deal of care must be taken.

In the February 1974 edition of Feed Situation, USDA economists used the 1971-72 survey information adjusted for projected volumes to estimate handling and storage costs for 1974-75. (11)

Table 1 shows the standardized book costs for handling grain projected in this study. Table 2 details the projected average replacement costs. "Average book costs more nearly represent the actual expected expenditure an elevator operator will incur, and average replacement costs reflect the expenses associated with a new elevator entering the industry." (11, p. 31)

The average costs developed by the USDA, Economic Research Service are therefore a useful starting point and probably the best source in current literature for average handling costs. But using these costs in the development of a new transportation model could leave the model open to question.

Even the latest (1974-75) projections are based on a survey of commercial elevators that were in existence in 1971. Many changes have occurred in the

Table 1

Standardized book costs, weighted average cost per bushel, for storing and handling grain, by area and type of facility, United States, fiscal 1974/75 1/

Area and type of facility	Received by-- Truck	Received by-- Rail	Received by-- Water	Loadout by-- Truck	Loadout by-- Rail	Loadout by-- Water	Storage
	Cents						
North Plains: 2/							
Country	2.14	--	--	1.71	2.04	--	11.08
Inland terminal	1.31	2.25	--	3.12	1.90	1.07	5.07
Port terminal	--	--	--	--	--	--	--
Mid-Plains: 3/							
Country	2.47	2.21	--	2.93	2.53	.68	9.41
Inland terminal	2.10	2.40	--	1.80	1.92	.72	7.26
Port terminal	--	--	--	--	--	--	--
South Plains: 4/							
Country	2.66	--	--	2.23	3.39	--	7.94
Inland terminal	2.08	2.17	--	2.13	1.65	--	8.21
Gulf port terminal	1.08	1.46	1.58	3.55	1.14	.80	18.14
West: 5/							
Country	2.12	--	--	2.64	3.03	--	9.67
Inland terminal	1.86	1.46	--	1.85	1.29	.76	9.85
Port terminal	2.23	1.97	1.92	2.39	2.25	1.11	17.06
Great Lakes: 6/							
Country	2.12	--	--	2.64	3.04	1.80	13.77
Inland terminal	1.71	1.81	4.46	.64	1.57	.31	7.46
Port terminal	1.49	1.56	1.95	1.61	1.71	.94	7.37
South and East: 7/							
Country	1.46	1.74	4.39	3.08	3.24	1.04	14.54
Inland terminal	2.10	1.50	4.02	2.32	2.94	2.10	6.68
East port terminal	2.56	1.16	2.61	4.11	3.22	1.47	7.18
United States:							
Country	2.22	2.12	4.39	2.52	2.70	1.12	10.60
Inland terminal	1.77	2.16	4.10	1.33	1.85	.79	6.97
Port terminal	1.47	1.51	1.61	2.97	1.72	.89	11.57
All facilities	2.12	1.77	1.79	2.42	2.42	.92	9.72

1/ Depreciation based on standardized depreciation rates applied to original acquisition cost of buildings and equipment.
2/ N. Dak., S. Dak., and Minn., (excluding port facilities).
3/ Nebr., Kans., Colo., Wyo., Iowa, and Mo.
4/ Okla., N. Mex., and Texas plus all Gulf port facilities.
5/ Wash., Oreg., Idaho, Mont., Calif., Ariz., Nev., and Utah.
6/ Wis., Ill., Ind., Ohio, Mich., and Minn. port facilities.
7/ Ark., Miss., S.C., Tenn., Ky., N.Y., Va., Pa., N.J., Md., Del., La., Ala., Ga., N.C., W. Va., and New England. (All Gulf ports are included in the South Plains.)

Source: FdS-252, February 1974, p. 35.

Table 2

Replacement costs, estimated weighted average cost per bushel, for storing and handling grain, by area and type of facility, United States, fiscal 1974/75 1/

Area and type of facility	Received by--			Loadout by--			Storage
	Truck	Rail	Water	Truck	Rail	Water	
	Cents						
North Plains:							
Country	2.32	--	--	1.84	2.24	--	18.35
Inland terminal	1.53	2.68	--	5.48	2.50	1.27	9.81
Port terminal	--	--	--	--	--	--	--
Mid-Plains:							
Country	2.65	2.33	--	3.16	2.94	.71	17.14
Inland terminal	3.07	3.42	--	2.49	2.47	.87	18.73
Port terminal	--	--	--	--	--	--	--
South Plains:							
Country	3.15	--	--	2.62	4.62	--	18.70
Inland terminal	3.18	3.52	--	3.91	2.90	--	26.60
Gulf port terminal	1.43	1.97	1.68	5.55	1.64	.95	26.08
West:							
Country	2.53	--	--	3.28	3.46	--	20.51
Inland terminal	2.29	1.71	--	2.64	1.52	.97	16.67
Port terminal	3.27	2.42	2.55	4.26	3.53	1.39	30.05
Great Lakes:							
Country	2.17	--	--	2.79	3.16	1.74	18.00
Inland terminal	1.98	2.31	6.05	.79	1.93	.34	13.23
Port terminal	2.71	2.43	3.56	3.78	2.81	1.34	23.19
South and East:							
Country	1.53	1.82	4.48	3.36	3.53	1.01	21.77
Inland terminal	2.23	1.78	3.85	3.21	3.26	2.00	11.84
East port terminal	4.00	2.00	3.91	10.87	6.70	2.12	23.54
United States:							
Country	2.39	2.25	4.47	2.76	3.04	1.12	18.18
Inland terminal	2.29	2.97	4.28	2.02	2.49	.90	16.72
Port terminal	2.50	2.19	1.79	6.41	2.84	1.13	25.03
All facilities	2.39	2.50	1.96	2.72	2.88	1.08	18.44

1/ Depreciation and interest on investment based on replacing building and equipment at 1974/75 price levels.

Note: See table 1 for delineation of areas.

Source: FdS-252, February 1974, pp. 34.

grain marketing sector since that time, and significant technological advances have taken place. Many elevators in the North Plains have installed facilities for loading multiple car rail units. These involve high fixed costs with average cost advantages at high volumes. Similarly, significant modernization has taken place at Gulf Port terminals since 1971. Another problem that might arise in the use of the average costs for a transportation model is the fact that a significant amount of branch rail line abandonment seems probable in the future. This would likely change grain flows and the type of grain handling facilities necessary. A change in handling costs would likely accompany these changes.

Use of historical industry-wide average costs becomes more unacceptable if examination of optimal transport systems and preferred future developments is the objective. For these purposes we want to look at the most efficient operations presently in existence and new processes that are under development.

In their study of alternative grain systems in the Fort Dodge, Iowa area, Baumel et al developed handling cost data. (1) In analyzing handling costs, they surveyed the elevators in the study area to determine: numbers, size, location, and handling and storage capacities. The study delineated two types of elevators: country and subterminal, depending upon whether the grain they received came mostly from the farm or from other elevators, and upon their load-out capabilities.

The study also differentiated between soybeans and other grains in calculating costs. Marginal costs were estimated for loading out and receiving soybeans and other grains (Table 3). These costs were based on actual company records and were considered independent of volume. The operating cost information included costs of receiving, conditioning, elevating and loading out grain. Also affecting costs were changes in quality and condition of grain handled and stored at different times throughout the year. This becomes particularly important in analyzing handling capacities. ERS-501 was used to determine variable costs for loading out grain at country elevators. ERS-513 was used to calculate average transfer costs for truck/rail receipt and barge shipment. Synthetic plants to accomodate different volumes were built using information from elevator operators and people in the construction industry. Investment costs were included as an element in future cost considerations only when the model dealt with new facilities or expansions of existing facilities.

The Baumel study estimated variable costs for handling grain in subterminal elevators. This elevator type was not clearly identified in the ERS Series. The variable costs were estimated by accounting techniques (Table 4). They are based on information from one subterminal elevator which loaded out 100 car grain trains. Elevators in Minnesota are currently loading out smaller 25 and 50 car units. Similar methodology could probably be used to develop cost functions for elevators in Minnesota.

Fedeler's analysis of domestic grain transportation used ERS-513 as a base for determining handling costs. (3) They calculated loading and receiving costs by grain and mode (Table 5). They examine what would happen to the

Table 3

Terminal Costs from the Baumel Study

Marginal Storage Costs

Corn:	1.04 ¢/bu.
Soybeans:	1.97 ¢/bu.

Marginal Receiving Costs

	Pts. of moisture removed	Cost
Corn:	10	4.58 ¢/bu.
	4	2.90 ¢/bu.
	0	1.78 ¢/bu.
Soybeans:		1.78 ¢/bu.

Marginal Load-Out Cost

Subterminal:	.55 ¢/bu.
Country:	1.74 ¢/bu.

Table 4

Estimated Variable Costs of Receiving, Drying, Storing and Loading Out Grain at a Subterminal in Cents per Bushel.

Cost Item	Receiving		Drying		Storage		Load Out		
								Cost	
	Percent Allocated	Cost	Percent Allocated	Cost per point	Percent Allocated	Cost per month	Percent Allocated	50 Percent Elevated	100 Percent Elevated
Direct labor	67	1.03	16	.10	7	.05	10	.15	.15
Repairs and maintenance	28	.10	10	.02	50	.08	12	.04	.08
Fuel, power and lights	25	.13	20	.05	40	.09	15	.07	.15
Drier fuel	--	--	100	.11	--	--	--	--	--
Administrative expense	60	.52	--	--	20	.08	20	.17	.17
Insurance on grain	--	--	--	--	100	.04	--	--	--
Total cost per bushel		1.78		.28		.34		.43	.55

Source: NITS PB 224-819, pp. 181.

Table 5

Grain elevator receiving and loadout costs per ton by grain and mode.[a]

	Wheat and soybeans	Corn and grain sorghum	Oats	Barley
Receiving				
truck	$ .700	$ .750	$1.313	$ .875
rail	.787	.843	1.475	.983
water, gulf	.517	.554	.969	.646
water, west	.807	.864	1.513	1.008
water, lakes	1.210	1.296	2.269	1.512
water, inland	1.243	1.332	2.331	1.554
Loadout				
truck	.793	.850	1.488	.992
rail	.843	.904	1.581	1.054
water, lakes	.430	.461	.806	.537
water, other	.337	.361	.631	.421

[a]Data in this table were calculated from selected costs in Table 3 of [3].

Source: CARD 54t, pp. 44.

flow of grain in lieu of different export demands and various rail and barge rates. They note the importance of including handling costs in their study but did not see a need for updating Economic Research Service cost estimates. Their study did determine that: "Handling costs comprise a larger share of transportation costs for trucks and for soybeans because their average shipping distances are shorter compared to other modes and grains." (p. 108)

The U.S. Railway Association studied the impact of branchline abandonment. (15) Their figures indicated the impact of transfer costs upon total transportation costs. As the volume increased the handling costs, which are over volume only, become less important and the mode of transportation, which involves distance as well as volume, becomes more important (see Table 6).

How relevant is the information on grain handling costs currently available in the literature for a study of the Upper Mississippi River Basin? Because the study area involves so many different country elevators, cost data supplied by ERS is the most reasonable source for costs for this group. This information would have to be updated. Information from studies of specific areas could be used to check this data or to analyze costs more thoroughly as Baumel did. (1) For example, a study of costs associated with country elevators in Minnesota Development Region 6E is currently in progress in the Department of Agricultural and Applied Economics at the University of Minnesota.

Elevators with multiple rail-car loading facilities should be dealt with separately. Since this is a smaller elevator group involving new technology and newer equipment, cost estimates can be obtained through elevator surveys

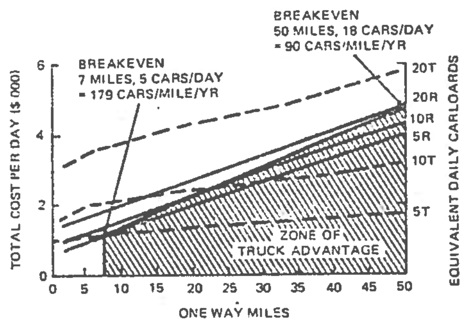
Table 6

Commodity type	Length of haul (miles)				
	5	10	20	35	50
Unitized or palletized freight	$3.62	$3.96	$4.41	$4.95	$5.72
Piggyback trailers	3.32	3.66	4.11	4.65	5.42
Granular/liquid bulk commodities	2.87	3.21	3.66	4.20	4.77

COMPARATIVE

RAIL-TRUCK COSTS

FULL ECONOMIC COST BASIS



ASSUMPTIONS:
1. NORMALIZED MAINTENANCE
2. REHABILITATION TO 30 MPH STANDARD
3. 10% COST OF CAPITAL
4. CURRENT (1974) REPLACEMENT COSTS
5. AVERAGE CARLOAD OF 55 TONS, BULK COMMODITIES
6. "ENGINEERED" TRANSFER TERMINAL COSTS

LEGEND
R —— RAIL COSTS
T- - - TRUCK COSTS (INCLUDING CARGO TRANSFER)

Source: United States Railway Preliminary System Plan, Vol. I, p. 106.

or by constructing synthetic plants. Some differentiation may be necessary among facilities of this type in Minnesota and the Dakotas and Montana.

Terminal elevators both on the river and at Gulf port locations have, thus far, been reluctant to give cost information. This information might be obtained from ERS data, except for analysis of the most efficient systems available. In that case, since there are relatively few of these facilities, synthetically building efficient port facilities based on developed and developing technology would be appropriate.

Ports on the Atlantic coast could probably be handled similarly. But Northwestern ports would probably have to be singled out as a subset of the ERS's "Western Ports." Synthetic facilities could be developed for that area based on the potentials of deep-water port development and new facilities now under construction.

A 1972 Institute of Water Resources Study indicated that the development of deep-water ports off shore for dry bulk commodities was not economically justifiable. (7) Most present ports pose draft constraints to deep draft vessels, though this is not the case with Puget Sound. The study did point out that further developments of restricted-draft vessels and/or incremental deepening of some ports for dry bulk commodities could be economically sound. But in view of the relatively short distances involved in shipment from Pacific ports, they did not see the need to study, in detail, deep-water port alternatives on that coast.

GRAIN STORAGE COSTS

Storage can be considered separately or as an element of the entire grain handling function. In any case, storage plays an important role in the grain transportation network. Storage serves as a means to help smooth the flow of grain throughout the year. This allows for a more efficient use of transportation equipment. Storage furnishes a surplus for periods of low production and provides a buffer in the maketing flow to ease problems of bottlenecks.

The cost of storage is a factor in the marketing bill. Grain cannot, after all, be totally consumed on the day it is harvested. We might, then, expect storage costs to affect the flow of grain.

There has been some work done on the cost of storing grain. The previously cited series by the Economics Research Service included a breakdown of average standardized book costs and average replacement costs, per bushel, by region and type of facility. (9, 10, 11) Tables 1 and 2 give the most recent findings. (11) These tables indicate substantial cost differences both by area and by type of facility. Again, the reasons for these differences are not listed, but their existence implies a need for further study as part of any analysis of the efficiencies of alternative transportation modes. Storage costs, like handling costs, are broken down according to fixed and variable components of both average replacement costs and average standardized book costs. These costs are listed according to type of facility but not by region, although regional information is included in ERS records. Table 7 shows the fixed and variable cost components for handling and storage released most recently by the ERS. (11)

Of course, storage costs per bushel can be expected to vary considerably with the volume of storage and the duration of storage. Storage space involves a fixed capital expense with relatively little variable cost. Therefore, per bushel costs will vary inversely with occupancy and volume.

The previously cited study by Baumel et al treated storage costs as a

Table 7

All facilities: Weighted average book and replacement costs per bushel for storing and handling grain, United States, fiscal 1974/75

Cost item	Received by-- Truck	Received by-- Rail	Received by-- Water	Loadout by-- Truck	Loadout by-- Rail	Loadout by-- Water	Storage
	Cents						
Fixed costs							
Building & equipment							
Insurance	0.020	0.014	0.016	0.029	0.028	0.007	0.614
Taxes	.032	.035	.011	.048	.046	.011	1.177
Leases	.026	.044	.118	.023	.023	.040	.862
Depreciation 1/							
Book	.138	.095	.083	.200	.164	.051	1.726
Replacement	.285	.571	.243	.347	.428	.168	5.290
Interest on investmant							
Book	.024	.018	.013	.032	.024	.012	.732
Replacement 2/	.164	.314	.138	.200	.241	.101	6.750
Licenses & bonds	--	--	--	--	--	--	.132
Total fixed cost							
Book 3/	.240	.206	.241	.332	.285	.121	5.243
Replacement 4/	.501	.934	.408	.624	.743	.287	13.963
Variable costs							
Direct labor	.748	.828	.728	.692	.887	.379	1.592
Administrative overhead	.528	.249	.102	.540	.439	.143	1.032
Electricity, heat, etc.	.094	.085	.071	.133	.122	.041	.091
Truck expenses	.113	.011	.005	.200	.087	.007	--
Building repairs	.004	.002	.002	.006	.004	.002	.523
Equipment repairs	.121	.086	.125	.167	.165	.064	.103
Insurance on grain	--	--	--	--	--	--	.517
Taxes on grain	--	--	--	--	--	--	.124
Fumigation	--	--	--	--	--	.019	.161
Other 5/	.241	.278	.493	.309	.339	.127	.205
Interest on working capital 6/	.035	.026	.026	.044	.044	.013	.124
Total variable cost	1.884	1.565	1.552	2.091	2.137	.795	4.472
Total cost per bushel							
Book	2.124	1.771	1.793	2.423	2.422	.916	9.715
Replacement	2.385	2.499	1.960	2.715	2.880	1.082	18.435

1/ Standardized depreciation rates applied to book acquisition cost of capital assets and to the 1974/75 replacement cost of elevator assets.
2/ Calculated at 8.0 percent of one-half of the 1974/75 replacement value of building and equipment. 3/ Includes all fixed cost items. 4/ Excludes lease costs. 5/ Includes such items as supplies, audit, legal, and protective services, dues, subscriptions, travel, advertising and donations. 6/ Calculated at 7.0 percent of one-fourth of the total out-of-pocket cost.

Source: FdS-252, February 1974, pp. 37.

separate item in handling costs. (1) They arrived at marginal storage costs of 1.04 cents and 1.97 cents per bushel of corn and soybeans, repectively, from company records and personal interviews. Variable storage costs, after interest payments, were calculated to be .34 cents.

The marginal storage costs included an allowance for expenses incurred in anticipation of future expansion of old facilities and construction of new elevators.

Table 4 gives the estimated variable storage costs found in the Baumel study. Table 8 lists estimated annual costs of storage facilities based on synthetic facilities with storage capacities of 300,000 bushels, 500,000 bushels and 1,000,000 bushels.

In a 1973 study Schnake and Tranzmann used standard storage charges of CCC's Uniform Grain Storage Agreement "because elevator operators' charges for storing commercial stocks of grain seemed to be closely related to the negotiated charges paid by the CCC." (8, p. 6) This method was chosen initially in an earlier study by Leath because: (4)

> "Average per bushel cost for a firm is highly dependent on capacity utilization, with average cost decreasing as the percentage of capacity utilized increases. The employment of such functional relationships was not desirable since firms were not considered individually in the model; cost-volume relationships at the firm level would lose their meaning if the capacities of all firms were combined within a region. Furthermore, specifying an average cost per bushel

Table 8

Estimated Installed and Annual Cost of Storage Facilities by Size of Capacity.

Cost Item	Years for Depreciation	300,000 Bushels	500,000 Bushels	1,000,000 Bushels
Silos and Tunnel	50	$210,000	$300,000	$550,000
Aeration and Heat Detection Equipment	10	10,500	17,000	28,000
Conveyors	10	16,720	33,440	66,880
Land	--	10,000	10,000	12,500
Total Installed Cost		$247,220	$360,440	$657,380
Annual Equivalent Cost	10 years	$ 4,430	$ 8,209	$ 15,442
	50 years	21,181	30,258	55,473
Annual Insurance and Tax @ 3.6% of Installed Cost		8,900	12,976	23,666
Total Annual Cost		$ 34,511	$ 51,443	$ 94,581

Installed cost ($) = 69,240 + 0.587 (x bushels).
Annual cost ($) = 8,638 + 0.086 (x bushels).

Source: NITS PB-224 819, pp. 187.

per quarter would not be realistic, since the volume stored in any region in a particular quarter was determined within the model and varied from one quarter to the next.

Incorrect specification of storage cost could introduce serious distortions into an optimum solution. Given this fact and the difficulties involved in specifying regional storage costs, the decision was made to use the standard storage charges of the CCC's Uniform Grain Storage Agreement." (8, p. 27)

However, the Leath Study used 1966/67 data, and this approach may not be appropriate today considering the significant declines in CCC storage that have taken place since that time.

Little was found in the literature specifying the storage cost element of other high volume bulk commodities that move along the river. It appears that further study will be necessary to deal with this element in a model of the transportation system.

CAPACITY CONSIDERATIONS - TERMINALS

In speaking of the effects of terminal capacity on the transportation system, we are interested in two important elements: handling and storage. In general, storage capacity is easier to define. Storage capacity involves strictly volume. Handling capacity is a rate concept and is more difficult to define and determine. In speaking of handling capacity we will be concerned with two basic processes: loading and unloading. The movement of a commodity through the facility is generally included with either the loading or unloading functions in discussing handling capacity. Terminal capacities and needs will be different for different commodity groups. It, therefore, becomes useful again to study terminal capacity by commodity.

GRAIN

Here we want to determine at what point terminal facilities become a bottleneck in the transportation of grain. Grain is normally handled at a number of junctures along the transportation path: the farm, country elevators, inland terminals and subterminals, processing plants, and port terminals. In periods of heavy movements, delays at any of these points will increase congestion in the handling facilities feeding it. In addition, segments in the grain marketing systems that cause disruptions in the grain flow can cause strains upon the sectors they feed.

The heaviest strains are placed on grain handling equipment during and immediately following harvest. This is borne out in a Minnesota State Planning Agency report which shows peaks in grain marketing occurring in August (when oats, wheat, and barley are harvested) and in November (when corn and soybeans are or have been harvested). (5) They note the importance of the cyclical nature of the yearly marketing pattern: "Variations in marketing characteristics have a very noticeable effect on the cost of transportation, the efficiency of transportation, and the amount of transportation equipment available at any one time." (5, p. 21)

Based on an analysis of monthly grain sales for the years 1968-1973, the study suggests that there is a limit of somewhat over 60 million bushels per month on the capacity of the Minnesota transportation system to move grain. How do handling and storage facilities affect that limit? To answer this question we need to analyze the flow of grain, the facilities, and the options available within each flow. This is no easy task. "Actual grain flows are difficult to trace and any inefficiencies or rigidities in the grain marketing system are not easily identified." (13, p. 75)

All of the grain moving down the Mississippi out of Minnesota ports leaves the state, with most of it destined for export via transshipment at Gulf ports. For the purposes of this study, this flow of grain is of particular interest. Large volumes of grain leave the state through three major channels: inland unit-train loading facilities, Mississippi River ports and ports on Lake Superior. It therefore becomes important to analyze the handling and storage capabilities within each of these channels.

There does not appear to be any published source giving handling capacities of elevators beyond very limited regional analyses. There is, however, information concerning storage capacity.

The State of Minnesota, Department of Public Services, issues two kinds of elevator licences. Most elevators in the state have state warehousing licenses. The list of elevators with state warehouse licenses includes the location and storage capacity of each elevator. All elevators in the state that buy grain for resale must have a state grain buyers license. This is true whether or not they have a state warehousing license. The list of elevators with buyers licenses includes storage capacity, but not handling capacity.

Some elevators have federal rather than state warehousing licenses. The list of federally licensed elevators includes location and storage capacity, but not handling capacity. The federal licensing agency does have information on the handling capacities of licensed elevators. However, this information is confidential.

Inland Unit-Train Facilities

A study by Dahl and Martin determined that as of August 1974, 19 elevators in southern Minnesota with a total storage capacity of 10.5 million bushels had loaded out unit trains. (2) 1.5 million bushels of storage space was being added to these facilities. The remodeling of 2 country elevators and construction of 5 new elevators would add 2.7 million bushels of storage space to the total by January 1975. This gives a total storage capacity of 14.7 million bushels.

The facilities are efficient, fast-loading operations so, in terms of capacity, grain handling capabilities become very important. There are no figures for the handling capacity of these elevators, although the Dahl-Martin study suggests that the 19 elevators functioning on August 1, 1974 had turned their storage capacities over on the average of 5.9 times per year. The importance of further study of individual elevators can be seen from the diversity within the group. Country elevators turned over on the average of 4.6 times and subterminals (defined as receiving more than half their grain from other elevators) had an average turnover of 19.5 times.

Therefore, the storage capacity of unit-train loading inland elevators is available in the literature, but handling capacity is not. Baumel et al in their 1973 study used an elevator survey to determine the size, location, storage capacity, and handling (loading, drying and unloading) capacity. (1) Because of the relatively small number of elevators involved, this approach could reasonably be used to obtain the handling capacity of unit-train loading facilities in Minnesota.

Lake Superior Ports

The annual reports of the Minneapolis Grain Exchange list the elevators within the Duluth-Superior switching district and their storage capacities. (19) Table 9 gives figures from the 91st Annual Report covering 1973. This appears to be a good source for storage capacity but, again, there is no published information on handling capacity. Here also, however, a small number of facilities are involved, and we would expect that this information could be ascertained through a survey.

River Terminals

The Grain Exchange annual reports also list the storage capacities of elevators within the Minneapolis-St. Paul switching district. This list is reproduced in Table 10. A switching district is an area within which rail cars can easily be switched and is defined by the railroad companies.

Table 10 shows that 13 of these elevators have barge-loading capabilities and can be assumed to ship grain by barge to the Gulf. These, plus 21 additional elevators on the list, have rail loading facilities. All but 4 of the facilities can receive grain by rail and most can also receive truck shipments.

Table 9

Elevator Capacity Within Duluth-Superior Switching District

	Location	Total Capacity In Bu.	Railroads	Switching District	Type of License	Construction	Means of Loading & Unloading: Load			Unload		Mechanical Sampling: Yes		No	Operator
							T	H	V	T	H	Load	Unload		
Capitol	Duluth	5,015,000	BN	Duluth	Fed.	Frame Ironclad Concrete	X	X	X	X	X		X		International Multifoods
Conners Point Warehouse	Superior	3,000,000	CNW	Superior	None			X	X		X			X	Great Lakes Storage & Contracting Co.
Continental	Superior	5,543,000	CNW	Superior	Fed.	Concrete & Steel	X	X	X	X	X	X			Continental Grain Co.
Duluth Dock & Transport Co.	Duluth	3,000,000	BN	Duluth	None			X	X		X			X	Duluth, Minn.
Elevator "A"	Duluth	2,670,000	BN	Duluth	Fed.	Concrete & Tile	X	X	X	X	X			X	General Mills, Inc.
Elevator "B"	Duluth	3,750,000	Soo	Duluth	Fed.	Concrete	X	X	X	X	X	X	X		Cargill; Inc.
Elevator "C" - "D"	Duluth	11,481,000	BN	Duluth	Fed.	Concrete & Tile	X	X	X	X	X	X			Cargill, Inc.
Peavey Co. Flour Mill	Superior	1,250,000	Milw.-BN	Superior	None	Concrete & Tile	X	X	X	X	X		X		Peavey Co. Term. Oper.
Elevators M & O	Superior	4,510,000	Milw.-BN	Superior	Fed.	Concrete	X	X	X	X	X			X	Elevators M & O, Inc.
Farmers Union	Superior	19,012,000	BN	Superior	Fed.	Steel & Concrete	X	X	X	X	X			X	Farmers Union GTA
Globe	Superior	4,246,000	CNW	Superior	Wis. St.	Wood Ironclad	X	X	X		X			X	Peavey Co. Term. Oper. Mpls.-Duluth
Great Northern Elevators S-X	Superior	13,480,000	BN	Superior	Fed.	Concrete, Steel Frame, Ironclad Sprinkler		X	X	X	X	X	X		ADM Grain Co.
		76,957,000													

T – Trucks
H – Hoppers
V – Vessels

Source: Minneapolis Grain Exchange. Ninety-First Annual Report for Year Ending December 31st, 1973. P. 61.

Table 10

Elevator Capacity Within Minneapolis-St. Paul Switching District

TERMINAL ELEVATORS	Location	Total Capacity In Bu.	Railroads	Switching District	Type of License	Construction	Means of Loading & Unloading: Load T	Load H	Load B	Unload T	Unload H	Mechanical Sampling Yes: Load	Mechanical Sampling Yes: Unload	No	Operator
Belco #1, #2, #5	St. Louis Park	3,959,000	CNW	Mpls.	Fed.	Wood Ironclad		X			X			X	Burdick Grain Co
Calumet	Mpls.	1,326,000	CNW	Mpls.	Fed.	Concrete & Steel	X	X		X	X			X	North Star Barge & Warehouse Corp.
Concrete	Mpls.	1,315,000	CNW	Mpls.	Fed.	Concrete		X			X			X	Peavey Co.
Consolidated "A"	Mpls.	1,056,000	CNW	Mpls.	Fed.	Brick, Concrete & Steel	X	X		X	X			X	North Star Barge & Warehouse Corp.
Continental Elev.	Mpls.	1,261,000	CNW	Mpls.	Fed.	Concrete		X			X			X	Continental Grain Co.
Delmar	Mpls.	14,272,000	CNW	Mpls.	Fed.	Concrete & Steel	X	X		X	X		X		ADM Grain Co.
Elevator "D"	St. Paul	2,209,000	CNW	St. Paul	Fed.	Concrete & Steel	X	X	X	X	X	X	X		ADM Grain Co.
Electric Steel	Mpls.	4,573,000	BN	Mpls.	Fed.	Steel	X	X	X		X			X	Peavey Co.
Farmers Union	St. Paul	5,252,000	BN	St. Paul	Fed.	Concrete & Steel	X	X	X	X	X	X	X		Farmers Union GTA
Great Northern	Mpls.	1,556,000	BN	Mpls.	Fed.	Ironclad Wood		X			X			X	Farmers Union GTA
Hampden	St. Paul	400,000	Minn. Tfr.	Mpls.	Minn. St.	Wood Cribbed, Steel Tanks	X	X		X	X			X	Handke Grain Service
"K"	Mpls.	2,319,000	Milw.	Mpls.	Fed.	Concrete & Steel								X	ADM Grain Co.
Kellogg "A"	Mpls.	541,3[illegible]	CNW	Mpls.	Minn. St.	Steel & Concrete, Ironclad Wood Workhouse		X			X		X		Spencer-Kellogg Div. Textron, Inc.
Kellogg "B"	Mpls.	1,338,000	CNW	Mpls.	Minn. St.	Steel & Concrete, Ironclad Wood Workhouse	X	X		X	X		X		Spencer-Kellogg Div. Textron, Inc.
Kellogg "S"	Mpls.	1,122,300	CNW	Mpls.	Minn. St.	Steel & Concrete Ironclad Wood Workhouse								X	Spencer-Kellogg Div. Textron, Inc.
"M"	Mpls.	1,383,000	Milw.	Mpls.	Fed.	Concrete								X	Farmers Union GTA
Marquette	Mpls.	4,030,000	CNW	Mpls.	Minn. St.	Concrete		X			X	X	X		Louis Dreyfus Corp.
Midway	Mpls.	3,347,000	CNW	Mpls.	Fed.	Ironclad Wood Storage, Concrete Tanks & Workhouse	X	X			X			X	Bunge Corp.
Monarch	Mpls.	1,314,000	Milw.	Mpls.	Fed.	Wood Cribbed		X			X			X	Searle Grain Co.
Peavey River Term.	Shakopee	1,115,000	CNW	St. Paul	Fed.	Steel & Concrete	X	X	X	X	X			X	Peavey Co.
Pillsbury Tile	Mpls.	400,000	BN	Mpls.	None	Tile								X	Pillsbury Co.
Pioneer	Mpls.	2,255,000	BN	Mpls.	Fed.	Steel		X	X		X			X	Peavey Co.
Port Bunge	Savage	9,307,000	CNW	St. Paul	Fed.	Steel & Concrete	X	X	X	X	X	X			Bunge Corp.
Port Cargill "C"	Savage	19,356,000	CNW-MNS	Mpls.-St. Paul	Fed.	Steel & Concrete	X	X		X	X	X	X		Cargill, Inc.
Port Continental	Savage	5,402,000	CNW	St. Paul	Fed.	Concrete		X	X		X	X	X		Continental Grain Co.
Pritchard	Mpls.	125,000	Soo	Mpls.	None	Ironclad Wood & Steel	X	X			X			X	Pritchard Grain Co.
Republic	Mpls.	1,822,000	BN	Mpls.	Fed.	Ironclad Wood	X	X	X		X			X	Victoria Elevator Co.
St. Anthony 1 & 2	Mpls.	1,837,500	BN	Mpls.	Fed.	Ironclad Wood, Tile & Steel		X			X			X	Peavey Co.
Checkerboard Grain Co	Mpls.	2,060,000	Milw.	Mpls.	Fed.	Steel & Concrete	X	X		X	X	X	X		Checkerboard Grain Co.
Shoreham	Mpls.	3,471,000	Soo	Mpls.	Fed.	Wood & Concrete	X	X	X	X	X			X	The McMillan Co.
Soo	Mpls.	4,923,000	Soo	Mpls.	Fed.	Concrete & Steel	X	X			X			X	ADM Grain Co.
"T"	Mpls.	4,047,000	Milw.	Mpls.	Fed.	Steel Workhouse, Concrete Tanks	X	X		X	X	X	X		Cargill, Inc.
Twin City "A"	Mpls.	2,277,000	BN	Mpls.	Fed.	Concrete & Steel		X			X			X	ADM Grain Co.
Union	Mpls.	1,649,000	BN	Mpls.	None	Concrete & Steel		X			X			X	Froedtert Malting Co.
Victoria "G"	Mpls.	661,000	BN	Mpls.	Fed.	Concrete & Steel	X	X	X		X			X	Victoria Elevator Co.
Victoria "R"	Mpls.	1,203,000	BN	Mpls.	Fed.	Ironclad Wood Workhouse, Tile & Concrete	X	X	X	X	X	X			Victoria Elevator Co.
Searle River Term.	St. Paul	1,058,000	CNW	St. Paul	Fed.	Steel & Concrete	X	X	X	X	X	X	X		Searle Grain Co.
Washburn	Mpls.	5,382,000	CNW	Mpls.	Fed.	Concrete		X	X	X	X			X	General Mills, Inc.
Total Capacity		131,948,100													

T – Trucks
H – Hoppers
B – Barges

Source: Minneapolis Grain Exchange. Ninety-First Annual Report for Year Ending December 31st, 1973. P. 60.

Beyond this, we can determine nothing about the handling capabilities. Again, this elevator group is small enough that a survey approach could likely be used to gather information. In this group we are faced with an additional problem. There are terminal elevators on the river that are within the St. Paul District of the Corps of Engineers, but outside the Minneapolis-St. Paul switching district. These would likely show up in listings of state and federal licensing agencies but, as Table 10 shows, not all terminal elevators have licenses.

The Final Environmental Impact Statement concerning the operation and maintenance of the 9-foot navigation channel within the St. Paul District indicates that grain moves out of at least one terminal in Pool 5, two in Pool 6, one in Pool 9, and three in Pool 10. (14) The information is not specific as to the precise number of grain terminals within each pool, their storage capacity, or their handling capacity. Nor does this information appear very complete. Further research would be necessary to assure inclusion of all river terminals within the district. This information does not appear to be present in current literature.

An important constraint on the barge movement of grain is weather. The Mississippi River is normally closed to barge traffic during the winter months. This means that what grain cannot be stored during these months must be shipped by rail or trucks. This tends to lure away potential river traffic.

Country Elevators

The above three elevator groups receive grain mainly from country elevators. Some of the unit-train loading elevators are, in fact, country elevators receiving most or all of their grain directly from the farm. Most grain leaving country elevators is destined for terminals and subterminals within the state rather than long-haul rail or barge movement.

During stress periods in the grain transportation system, country elevators, being sources of grain, act as buffers for the terminal elevators. Grain is assembled in country elevators so that it can be moved through terminal and subterminal facilities more efficiently, arriving by semi-truck and rail. Country elevators are depended upon for a steady flow of grain so that rail and barge commitments can be met.

The Minnesota State Planning Agency study (5) noted that there were more than 600 country elevators in the state. There is no complete list published giving the number, handling capacity, or storage capacity of country elevators in Minnesota. The Minnesota Crop and Livestock Reporting Service has a list of all of the elevators in the state and their storage capacities, but the list is confidential. Each year their figures for total off-farm grain storage capacity in the state are published in the USDA publication, Stocks of Grain in All Positions. (21) The publication gives a gross figure including storage in elevators, terminals, mills, processing companies, oil seed crushers and the like. Certain storage units such as those of Commodity Credit Corporation bins and seed companies are excluded. The Crop Reporting Service reported the off-farm storage capacity for Minnesota for 1973 to be 352.7 million bushels. This is a very gross total from which we can deduce nothing about country elevators, or any other of the elevator groups for that matter.

Federal and state elevator license listings are the best source available to ascertain the number, location, and storage capacities of elevators in the state. There will be problems using this approach for country elevators. It will take some analysis to separate out country elevators from this list. Not all elevators are licensed, and the licensed storage capacity of some elevators is not the same as their full capacity. The Crop and Livestock Reporting Service has found that a close comparison exists between actual storage capacities and the storage capacities licensed with the state by specific elevators. They did note some variation, however.

Yager et al used license listings to determine the storage capacity for the elevators in the area they studied in 1973. (16) This was a much smaller study area, only 7 counties, and involved only 112 elevators including country and terminal elevators and processing plants.

Minnesota State Planning used federal and state license lists to estimate the total storage capacity of country, subterminal, and terminal elevators in the state at around 225 million bushels. (5) There is a significant difference between this figure and the 352.7 million bushel estimate of the Crop and Livestock Reporting Service. This indicates the impact of assumptions made in using and interpreting license data.

Handling capacities for country grain elevators would be very hard to determine on a state-wide basis. Perhaps the only way to get this information would be to survey a representative sample of elevators and extrapolate from the sample.

The Farm

The importance of on-farm storage capacity in the grain marketing pattern should be noted. A USDA presentation before the U.S. Senate indicated that in 1971 Minnesota had a total on-farm storage capacity of around 325.5 million bushels. (13, p. 65) Storage capacity on the farm, as well as the capabilities of farmers to harvest grain and move it to market, has a significant impact on the grain transportation system, especially at harvest. As pointed out in the State Planning study, "It is certain that all existing capacity on and near the farm will be needed and it is very likely that increased storage capacity will be needed to meet the expected increase in production and the longer holding times resulting from the more even flow of sub-terminal shipping." (5, p. 78)

Port Facilities

Most of the grain moving out of the St. Paul District by river is destined for export. River ports are, therefore, competing with other ports for export grain. An examination of export port facilities and their capabilities thus seems in order. Minnesota grain is exported from the U.S. via 4 major port regions: Lake Superior (through Duluth-Superior), Gulf ports (transshipped from rail and barge), East Coast ports (transshipped from rail), and Pacific Northwest ports (transshipped from rail).

Grain will move out of Minnesota to the ports offering the best prices net of transportation costs. Prices at the ports will depend on outstanding export contracts, availability and cost of ocean shipping, and shipping costs to the port. "Because of location of production, availability of transportation facilities, and the existing rate structures, grain and soybean exports follow definite patterns and port areas tend to be 'grain specialized.'" (13, p. 75) This can be clearly seen from Table 11. At Duluth-Superior wheat predominates. The Mississippi Gulf tends to specialize in corn and soybeans. Corn is the major grain leaving North Atlantic ports. Wheat predominates at ports in the Pacific Northwest.

In general, we will find the same problems as already discussed in determining storage and handling capacities for port elevators. Storage capacity plays a very major role in the operation of these facilities. "Although these have storage space, the capacity is used primarily for the accumulation of grain prior to the loading of ocean-going ships rather than for long-term storage. Such accumulation is necessary because a large ocean-going ship can carry about 80,000 long tons of grain, and loading a ship of this capacity requires inventories at a port elevator of about 3 million bushels. Loading of ships directly from trucks and rail cars is impractical because a large ship would hold an equivalent of about 900 rail hopper cars. Scheduling the arrival of such a volume exactly when ships are ready for loading would be practically impossible." (4, p. 22)

Inadequacy of handling and storage capacity at port elevators caused a notable bottleneck in the grain transportation network during the "crunch"

Table 11

TABLE 3.5—SELECTED GRAIN AND SOYBEANS INSPECTED FOR EXPORT BY PORT AREA, 1972 AND 1973[1]

[In million tons]

Port area[1]	Wheat		Corn		Grain sorghum		Soybeans		Total	
	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973
Lakes:	2.4	4.0	3.7	4.2	(2)	(2)	1.9	2.0	8.0	10.2
Chicago	(2)	.1	1.7	2.1	(2)	(2)	.7	.9	2.4	3.1
Duluth-Superior	2.3	3.9	1.9	1.4	(2)	(2)	(3)	.1	4.2	5.4
Toledo	.1	(2)	.1	.6	(2)	(2)	1.1	.9	1.3	1.5
Saginaw	0	(3)	(2)	.1	(2)	(2)	.1	.1	.1	.2
Atlantic:	1.0	2.3	4.3	7.1	(2)	(2)	1.1	1.6	6.4	11.0
North	.3	.6	1.3	2.5	(2)	(2)	.3	.3	1.9	3.4
South	.7	1.7	3.0	4.6	(2)	(2)	.8	1.3	4.5	7.6
Gulf:	12.6	24.6	16.1	24.1	4.1	5.6	10.1	10.8	42.9	65.1
Mississippi	2.8	2.7	15.4	22.0	.5	(3)	8.2	8.8	26.9	33.5
East Gulf	.6	2.1	.2	.4	(2)	(2)	1.1	1.0	1.9	3.5
North Texas Gulf	8.6	17.7	.5	1.6	1.5	2.3	.8	1.0	11.5	22.6
South Texas Gulf	.6	2.1	(3)	.1	2.0	3.3	(2)	(2)	2.6	5.5
Pacific:	7.5	10.3	(3)	.1	(3)	.3	(2)	(2)	7.5	10.7
Columbia River	5.8	7.1	(2)	(2)	(2)	(2)	(2)	(2)	5.8	7.1
Puget Sound	1.7	2.5	(2)	(3)	(2)	(2)	(2)	(2)	1.7	2.5
California	(2)	.7	(3)	.1	(2)	.3	(2)	(2)	(3)	1.1
Total	23.5	41.3	24.1	35.4	4.1	5.9	13.1	14.4	64.8	97.0

[1] Lakes—Chicago; Chicago and Milwaukee; Toledo: Toledo; Saginaw: Saginaw, Carrollton, Milwaukee, Detroit Atlantic—North: Portland, Albany and Philadelphia; South: Baltimore, Norfolk and North Charleston. Gulf—Mississippi River: New Orleans, Destrehan, Port Allen, Myrtle Grove, AMA and Reserve; East Gulf: Mobile and Pascagoula; South Texas Gulf: Corpus Christi and Brownsville. Pacific—Columbia River: Portland, Kalama, Astoria, Longview and Vancouver; Puge Sound: Seattle and Tacoma; California: Long Beach, Stockton, San Francisco, and Sacramento.

[2] None reported.

[3] Less than 50,000 tons.

Source: U.S. Dept. of Agriculture, Agriculture Marketing Service, "Grain Market News," various issues, 1972–74.

Source: U.S. Senate. Transportation in Rural America. Committee on Agriculture and Forestry, February 10, 1975. P. 76.

of 1973. When port elevators became "plugged," fully loaded rail cars and barges were, in effect, taken out of service and used for storage, often for days, until they were unloaded. This aggravated an already severe rail car and barge shortage that was affecting Minnesota grain elevators.

Lake Superior

Facilities at Duluth and Superior were discussed above. Most of the grain leaving these ports is wheat. It is destined mainly for flour mills in the Buffalo, New York area or for export. Lake Superior terminals compete with the Twin Cities to some extent for corn and soybeans out of the south-western part of the state, as well as for wheat.

In terms of capacity, a major obstacle faced by these ports is the seasonality of navigation on the Great Lakes. The Lakes are normally closed to shipping from mid-December through the end of March. While all of the terminals at these ports can ship by rail, this is not as economical and, in fact, may involve shipping grain right back through the areas it came from.

Another problem is that there are important vessel draft restrictions to navigation on the Great Lakes. These restrictions make it difficult to lure ocean-going vessels into the Lakes. In fact, many of the newer, more efficient ocean-going bulk carriers are unable to enter the Great Lakes. Many ocean vessels that load out grain from Duluth-Superior can only be partially loaded. They are then "topped off" at ports on Lake Ontario after they pass through the Welland Canal.

The Minnesota State Planning study (5) suggests that any substantial increase in the movement of grain from ports in Duluth and Superior will be possible only if changes are made in the Great Lakes St. Lawrence System "to make it more accessible to ocean-going vessels necessary to international grain shipments." (5, p. 69) Such changes, if significant, could well lead to a shifting of grain from Mississippi River ports toward the Great Lakes.

The study also says that there are three major factors that could affect the amount of grain moving through these ports: (1) if the amount of grain produced in Minnesota and surrounding states increases, there would likely be a greater demand by shippers for lake shipment, (2) increases in grain exports would likely increase demand for lake shipment, and (3) the amount of grain that can be handled will depend on the availability of vessels. (5, pp. 68, 69)

This seems to indicate that if grain production in Minnesota and surrounding states increases and/or export demand increases, and if the availability of ocean-going vessels on the Great Lakes does not increase, Minnesota export grain would have to move to other ports. This could mean an increase in demand by shippers for river or rail transportation.

Gulf Ports

Export grain moves to the Gulf from Minnesota by rail and barge. Generally the same problems as mentioned above exist in determining handling and storage capacities at Gulf port elevators. Both storage and handling capacities at these ports were constraining elements to grain movement in 1973. Ocean vessels sat idle at a cost of $3,000 to $5,000 per day as they waited to be loaded. (13, p. 111) At the same time, rail cars and barges were waiting, often for long time periods, to be unloaded.

With hopper cars and boxcars in short supply, any delay in unloading from rail cars at the Gulf limits the movement of grain by rail. On the other hand, with barge movements restricted by winter river closures, any delays in barge unloadings adds limits to the amount of grain that can be shipped by barge during the navigation season. What grain is not shipped by barge will likely be diverted to rail, assuming cars are available.

North Atlantic Ports

Because of the rate structure, there is not a substantial amount of grain moving out of Minnesota to Eastern ports. At some times, grain is drawn to the East Coast out of Minnesota. Not as much grain passes through Eastern ports as through Gulf ports. Bottlenecks occurred at Eastern ports in 1973, so that Southern movements of Minnesota grain were not diverted Eastward.

Pacific Northwest Ports

"West Coast port facilities typically handle smaller volumes and utilize capacity at lower levels than do Gulf exporters." (13, p. 115) But new terminal construction is taking place in this area. In the past, high rail rates and a shortage of ocean vessels moving to these ports limited the amount of grain moving out of Minnesota to the West. However, these ports are at times competitive with the Twin Cities and even Duluth-Superior for Dakota and especially Montana wheat. The elevator survey used by Minnesota State Planning for their study (5) even picked up some movement of corn to the West Coast out of Minnesota.

Any significant divergence of grain out of Minnesota to the West Coast could eat into river movements. But this appears unlikely in the short-run. Facilities are still lacking on the West Coast. Rail rates continue to be high. And there continues to be a shortage in the availability of vessels.

"There will probably be a gradual increase of grain moving west unless the federal government enters into a grain sale arrangement with the Far East, similar to the 1973 Soviet grain arrangement. Such an arrangement would likely cause rapid westward movement of grain." (5, p. 38)

One other event that could cause a significant increase in the westward movement of grain would be the development of deepwater port facilities for loading out dry bulk commodities. Such a development was not considered a likelihood by the U.S. Deepwater Port Study (7) completed in 1972.

COAL

Coal has traditionally moved into the St. Paul District from mines in the lower and eastern Midwest. However, the future movement of coal from these sources is very much in question. First of all, it is becoming more difficult for coal buyers in the St. Paul District to get long-term contracts for Midwestern coal. Secondly, environmental standards are making it less favorable to burn the high-sulfur coal that comes out of that area.

On the other hand, major Midwestern coal users are making long-term commitments for large volumes of coal from Montana, Wyoming and, to a lesser extent, the Dakotas. Coal from these areas has a much lower sulfur content. A study by the State of Montana in 1973 showed that considerable commitments had already been made by major utilities in Minnesota and surrounding states. (6)

According to the Project Independence Task Force Report: "Given the combination of complicating factors, many utilities, even in Eastern coal mining districts, are opting for buying Western low sulfur coal, making the needed plant changes to burn it, and setting up long-term contracts for supply. The high cost of transporting Western coal, which must travel 1,000 or even 2,000 miles to its markets, can be passed on to the consumer. In some cases, the utilities will be buying coal from their own mining subsidiaries. In many cases, Eastern coal could be burned more cheaply, even with stack scrubbers, but present regulations make Western coal the reliable, higher profit solution. Rapid progress in stack scrubber or desulfurization technology or changes in regulations could rapidly reverse the present situation." (17, p. II-38)

Because of the traditional movement of Eastern coal to the Upper Midwest via barge, many of the coal burning plants in this area are located on or near the river system. These plants are often poorly situated to receive Western coal directly by rail, being on either poorly kept rail lines or no rail lines at all. Another problem exists for some plants in that they do not use enough coal to take advantage of unit-train shipping rates for their coal. This makes for very high transportation rates for Western coal.

It is felt by many that the most economical means of supplying the coal requirements of these plants is to build one or more large transshipment facilities on the river system. In this way coal could be shipped from the West on unit trains to one of a few centralized terminal facilities that could take advantage of the most economic high-volume unloading techniques. From these facilities the coal could be transshipped by barge, rail, or truck to supply plants already set up to handle these transportation modes and/or too small to enable them to install new rail lines or efficient unloading facilities.

Adequate supplies of coal exist in the western U.S. to supply energy requirements for the Upper Midwest for many decades. The advent of coal transportation by 100 to 115 car unit-trains, and the efficiencies accompanying this development have made it economically feasible to ship coal from the West. The constraint to the movement of Western coal into this area seems to be in the development of terminal and handling facilities.

To achieve the efficiencies required for unit-train coal rates, train loading and unloading must be very rapid. For example, shippers must load an entire train within 24 hours and unload the train within 24 hours to take advantage of Burlington Northern's special 67 car train rate. For the even less expensive (per ton) 100 car train rates, the entire train must be loaded in 4 hours and unloaded in 4 hours. Such facilities are very expensive to set up and require high volumes of coal moving through them to pay off. Many of the large new coal burning power plants, such as NSP's Sherburne facilities, are planned to include such facilities.

The Project Independence Report used information from a Bureau of Mines publication in examining loading and unloading times.

> "The Bureau of Mines Information Circular 8444, Unit Train Transportation of Coal, analyzes mine representative unit coal train operations. Most facilities surveyed contained special trackage and equipment to expedite coal car loadings. Average loading times for approximately 100 car unit trains was between five and six hours, depending on the capacity of the facility. ICC listings of unit-train tariffs for these coal movements generally (specify) a maximum of five to six hours for loading.
>
> Unloading times at traffic destinations are generally more difficult to determine. Estimates of eight to twelve hours predominate in the Bureau of Mines report, although these seem unduly long. Unit-train tariff requirements specify that the empty hoppers be returned to the carrier road within one day to avoid detention charges of $10 or more per car per day. In that unloading time appears to vary substantially, it was decided to allow a maximum of twenty-four hours from delivery to user to return to carrier.
>
> Total loading and unloading times could reach a maximum of thirty hours for unit train operations, although this appear to be an upper-bound estimate." (18, pp. III-14, III-15)

The development of such facilities could be expected to add to or at least maintain current coal volumes on the river system, including the St. Paul District. In a paper presented to the National Conference on Water in April, 1975, Marvin J. Barloon noted that: "This is now taking place on a growing scale in the programmed unit train movement of low-sulphur coals from Wyoming and other western origins via the Burlington Northern Railroad to barging terminals in the St. Louis area and on the lower Ohio River." (22)

Northern States Power is currently transshipping Western coal with 67 car unit trains through Minneapolis. The coal is being received at NSP's Riverside transfer facilities in Minneapolis. A March 6, 1974 article in the St. Paul Pioneer Press noted that "About 1.8 million tons of coal are expected to be brought into the Riverside plant this year, with a million tons used at Riverside and the remainder shipped to NSP's Black Dog Plant in Bloomington and Allan King Plant at Bayport."

Coal is also being unloaded from 67 car unit trains at the Minneapolis Municipal Dock and transshipped into barges for use at facilities along the river.

According to NSP officials, their Highbridge plant in St. Paul presently receives 67 car unit trains of Western coal. The plant also receives Eastern coal by barge. The Black Dog and King plants receive Illinois coal by barge, as well as transshipped Western coal. Indications are that as years pass, lesser and lesser amounts of Eastern coal will be used by NSP.

In terms of barge unloading facilities, NSP's operations involve two different systems. The older plants each have systems involving the use of cranes. The average unloading time for a standard 1400 ton barge-load of coal at these plants is around 2 hours. The King plant employs a newer rotary unloader which averages around 45 minutes to unload 1400 tons.

According to the Project Independence Report, Rail-Water transfer facilities for the transshipment of Western coal have been proposed for Minneapolis/St. Paul, St. Louis, Missouri and Metropolis, Illinois for hookups with the Burlington Northern Railroad. A facility has also been proposed for Memphis, Tennessee, for a linkup with the Missouri Pacific Railroad. (17, p. V-49)

The St. Paul facility has been planned for an area close to Pig's Eye Lake on the Mississippi River in St. Paul. This facility would have the capacity to handle 7.5 million tons of coal annually. The terminal would have a storage capacity of 1.75 million tons. The coal would come into the terminal on 100 car unit-trains from the West. The unloading process would take place on a looped track where a rotary car dump is used. The open-hopper coal cars would have swivel couples so they could be dumped while still coupled to the train. The facility would have the capacity to unload a 100 car unit coal train in 4 hours. The coal would be unloaded directly from the trains into barges, with the excess going into the storage area. NSP's Sherburne facility is in the process of putting such coal unloading technology into operation. The site has no transshipment capabilities and receives no barged coal.

The proposed Pig's Eye facility already has 3.4 million tons of annual commitments from utilities that have plants on or near the river system, according to a February 26, 1974 article in the St. Paul Pioneer Press. The rest of the 7.5 million tons is expected to go to industrial users and other utilities.

At this point, however, it does not appear that the Pig's Eye site will be developed, at least on anywhere near the scale proposed. The Minnesota Pollution Control Agency has found that the site would generate excessive air pollution from fugitive coal dust. The PCA also felt that the 50-foot high coal piles used to store coal would cause visual pollution. On the basis of these findings, the Pollution Control Agency has turned down a request for permission to develop the Pig's Eye facility. The facility cannot be built without a permit from the PCA. It appears that any proposed barge transshipment site on the river would run into strong opposition on environmental grounds. For example, the St. Paul Pioneer Press of Saturday, November 9, 1974 carried an article about the very strong, negative response by residents of Diamond Bluff, Wisconsin to the possibility that a transshipment facility would be built in that area.

As noted in a May 21, 1975 article in the St. Paul Pioneer Press, however, new applications have been filed for permits to build a smaller facility at Pig's Eye. This operation would store up to 150,000 tons of coal in 20-foot piles. The new request was also rejected by the PCA, but appeals are possible and applications can still be submitted if the proposed facility is revised.

It might also be noted that NSP's Riverside transshipment facility has been criticized for the negative impact it has had upon the environment of the surrounding area. The major problem there is air pollution caused by fugitive coal dust. Various law suits have been brought against the company attempting to get the operation cleaned up.

It seems, therefore, that no large-scale rail-barge transshipment facility for coal is likely to be built within the St. Paul District in the near future. Future development will depend upon future court rulings and the ability of developers to straighten out environmental problems. Whether or not terminal facilities of this nature can be built in the St. Paul District will certainly affect the volume and form of coal traffic on the river system within the district. If facilities are not developed on the river, coal users can be expected to turn to increased rail and truck transshipment from facilities away from the river. Some coal might also move up river from rail-barge facilities like that in St. Louis.

The environmental costs of developing Western coal appear to be very high in the producing states as well. A great many legislative and judicial decisions must be made before the direction of that development is defined. What decisions are made will have significant impacts upon the availability of Western coal and the types of transportation systems developed. The development of coal gasification plants and mine-mouth electric generating plants would mean that smaller quantities of coal would be shipped directly into or through the St. Paul District. Under those circumstances, pipelines and high-voltage power lines would become a more significant means of transportation.

Environmentalists argue that development of Western coal should be restricted for a number of reasons. They feel that the water supply resources would be seriously strained if full scale development were undertaken. In a 1973 report the Montana Coal Task Force noted that: "In general, it seems safe to assume that a supply of water sufficient to accomodate the coal developments currently under consideration would require complete development of the area's water resources. This would not only mean more dams, but interbasin and interstate transportation of water through the network of pipelines proposed by the Bureau of Reclamation..... Provision of a readily available water supply would have far-reaching effects -- environmentally, socially, and economically." (6 , p. 10)

Officials are also worried about the consequences of the influx of large numbers of workers that would accompany coal development.

Another thorny question deals with the impact of stripmining upon the environment and the responsibilities of stripminers to return the land to its initial state after mining operations are completed. State and federal legislators are spending a great deal of time on this question. The rulings they make will have considerable impact upon the form and amount of coal development that takes place in the West.

What all this means is that the capacity and even the physical form that will be taken in the coal movement system are very much in question. Methods apparently exist to ship Western coal to the Midwest at economically feasible costs. The question now is; can the cost of developing mining and handling techniques that are environmentally acceptable be borne?

In terms of the overall effects of Western coal development on the transportation networks, the following findings by the Project Independence Report are interesting: "Seasonal shipments of agricultural products in the West could provide potential interference problems to coal movement. However, grain shipments would tend to congest terminal facilities, sidings and secondary routes rather than trunk lines of importance to unit train coal movement. If mixed cargo train operations are used to haul large quantities of western coal, severe interference problems with agricultural shipments could develop at some times and places." (17, pp. II-29, II-30) This situation could be exacerbated by the uncertainty regarding coal development. "With the many uncertainties in the coal transport situation and the prospects for rapid reversal of trends, cautious investors could be unwilling to invest in long term capital improvements in coal transport modes without long term hauling contracts. Similarly, the manufacturers of rail cars or barges could be unwilling to expand their plants without assurances of continuing business. As a result, these manufacturers will be more likely to go to multiple labor shifts to increase production and to maintain a sizeable backlog of orders rather than to expand plants to reduce the backlog." (17, p. II-38)

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CHAPTER VII

INTERMODAL COST COMPARISON

As discussed in Chapter 1, comparing costs in the transportation industry is difficult (if not outright hazardous) because of the conceptual problems of defining relevant costs, the statistical problems of estimating costs and because of the differences between costs from the point of view of shipper, carriers and society. In addition, transportation firms are not single product firms but provide a wide range of services. The costs per shipping unit (ton-mile) associated with different commodities may vary substantially within a mode. Consequently, average costs may have little meaning in many instances.

Friedlaender (2) states "In assessing the relative costs of the various modes, it seems to be generally agreed that long-run marginal costs are relevant carrier costs. Since these costs reflect society's valuation of the additional resources required to ..... produce an additional unit of output as efficiently as possible, long-run marginal costs reflect the inherent advantages ..... in making a given shipment."

Unfortunately, the only comparative estimates of long-run marginal costs by mode appear to be those of Friedlaender. Although still cited in recent studies, Friedlaender's cost estimates were for the year 1963. These estimates are included as Table 1. These cost estimates are "social" costs from the point of origin to point of destination and allow for pickup and delivery costs, terminal costs and a cost attributable to carrying in-inventory in transit as well as line-haul costs.

Table 1

Long-Run Marginal Costs for Optimal Freight Transport Operations, by Mode of Transport, 1963[a]

Mode of Transport	Marginal Costs (mills per ton-mile)
Pipeline	1.0
Water	
Manufactured commodities	4.0-5.0
Bulk commodities	1.0-2.0
Rail	
Bulk multiple car	4.0-5.0
Bulk boxcar	7.0
Piggyback	11.4
High-value commodities	15.6
Truck	21.7

a. Assumes shipments of 500 miles, capacity operations.

Friedlaender's barge cost estimate is composed of 3.0 mills for fully distributed costs, .7 mills for current capital cost and .3 mills for inventory carrying costs. Fully distributed costs include terminal costs and a return to overhead as well as the line-haul component which is estimated to be only .7 mill. Current capital costs were computed to cover operating and maintenance costs and new contruction. No cost was charged to old (existing) waterway construction.

Friedlaender's (2) rail cost estimates ranged from 8 mills per ton-mile for a 40 ton, 300 mile shipment to 4 mills for unit trains under favorable conditions. Oil pipeline cost estimates range from .6 mills for a 400,000 barrel a day pipeline to 3.7 mills for the least efficient operation with 1.2

mills being representative.

Friedlaender, writing in 1969, reached the following conclusions about the economics of bulk commodity transportation:

a. "Under proper conditions rail operations are competitive with barge operations. For this to happen, however, large shipment sizes are needed. Consequently, for all but the largest volumes of rail shipments, water transport probably retains a competitive edge over rail transport."

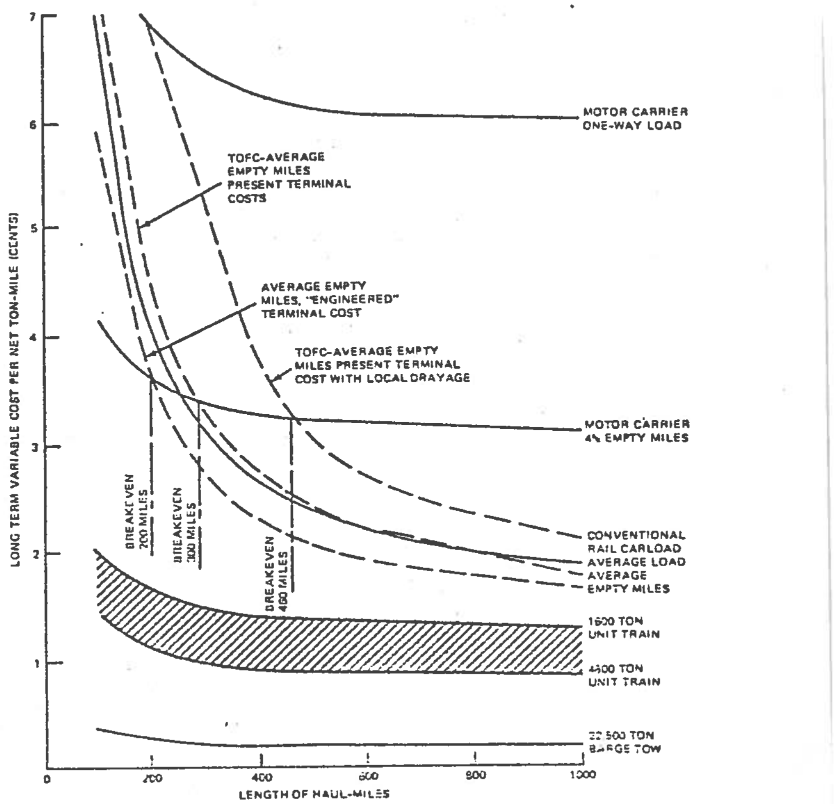
b. "At their most efficient level of operation, pipelines are very cheap..... Thus when (petroleum) pipelines can be utilized they are cheaper than any mode."

The U.S. Railway Association's Preliminary System Plan (3 , p. 299) compared the relative economics of different transportation modes. Their "full economic costs" are displayed as Figure 1. These are not historical average costs but are engineered costs for various specific configurations and are based on current replacement costs and interest rates. According to the authors, they are "estimates of true-long-run costs appropriate for investment planning." Note, however, that unlike Friedlaender's "social cost" which included pickup, delivery, and inventory costs, these estimates are limited to line-haul costs.

One interesting aspect of this particular analysis is that the line-haul costs of barges are substantially below that of unit trains, indicating a long-run advantage for barge transportation.

FIGURE 1

COMPARATIVE LINE-HAUL COSTS
FULL ECONOMIC COST BASIS



NOTES: 1. FULL ECONOMIC COSTS BASED ON PRESENT DAY EQUIPMENT REPLACEMENT COST, 10% CAPITAL COST, NO PROVISION FOR INCOME TAXES

2. NO ALLOWANCE FOR CIRCUITRY IN LENGTH OF HAUL

Source: USRA Preliminary System Plan, p. 299.

The study also mentions the legal limitations on truck sizes and weights which impose higher unit operating costs on trucks. They conclude that "if use of double-bottom (or even triple-bottom) units were to become legal..... trucking costs would be reduced somewhat, and perhaps be even lower than rail."

In their analysis of U.S. grain transportation, Fedeler, Heady and Koo (1) varied the relative costs of the transportation modes and analyzed the resulting changes in the amounts of transport. Changes analyzed included

10 and 20 % increases in rail costs and 10 and 20 % increases in barge costs. Assembling and handling costs were included in the models.

Although limited to grain, they concluded that rail is not competitive with water for moving grain from the Corn Belt to the Gulf if the grain is produced near the Mississippi River System. They also concluded that total costs of transportation and production are more sensitive to rail costs changes than barge cost changes. In their model, when rail transportation costs were increased, total rail costs increased proportionately. However, when barge costs were increased, part of the shipments were diverted from barges to another mode (rail). In fact, total barge costs decrease when barge costs are increased. This indicates that rail more readily substitutes for barges than vice versa.

Donley and Associates are currently analyzing prevailing transportation rates (not costs) for commodities which pass through Locks and Dam 26 at Alton, Illinois. The rates to be analyzed include the rate for the waterway route, the rate for the most likely all land alternative and the rate for a combination land-water route. Charges include the rates for loading the commodity at the origin and unloading at the premises of the consignee.

Although based on rates and not costs, the fact that the Donley study is to include all explicit charges for given commodity movements should make it a valuable intermodal study.

Conclusions

Any definitive statement about intermodal cost advantages must consider both general principles and specific situational variables. General principles include such things as the relationship of line-haul costs with distance and the ratio of fixed and variable costs. Situational variables include such things as the specific commodity, characteristics of the available equipment and the proposed routes, terrain, etc.

Basically, this means that we cannot say that one mode is superior to another unless we have defined the commodity, its origin and destination, its route, and the equipment configurations available for each mode. Costs of any mode can vary substantially between lines or routes. The costs of transporting a specific commodity may vary with distance or volume. Costs of pickup, handling and delivery may vary depending on mode. A mode which has quite favorable line-haul costs may be the high cost mode when all related costs are considered.

In addition, there are intangible "costs" which the public must bear that are impossible to measure in dollars and cents. These include air and water pollution, traffic congestion, and blighted landscapes. These effects which vary by mode, should be considered in determining the "best" mode for a given shipment between two points.

Having said that we can make some general statements that indicate which modes are likely to be competitive for the various types of bulk commodity transport, intangible "costs" and subsidies not explicitly considered.

1. Trucks have the highest operating costs per ton-mile and, consequently, are generally not competitive with rail or barge for low value bulk commodities (coal, sand, gravel) over long distances. Various studies have determined the distance and shipment quantities for which trucks have a cost advantage over rails. These distances decrease as shipment size increases.

However, because of the speed, flexibility and reliability of truck service and point to point delivery, trucks apparently can compete with rails over long distances for high value bulk commodities, i.e., canned goods, manufactured goods, etc., especially if back hauls are available. Water transport is generally not competitive for these commodities because of the inventory value and the pickup and delivery costs.

Truck costs are below rail for grain movements up to about 60 miles and competitive up to 100 to 125 miles. Beyond 125 miles, rail costs are probably less, especially if multiple car procedures or unit trains are available. However, there are conditions where it would be economical to ship grain substantially beyond the 125 miles by truck rather than incurring the terminal costs required to transfer the shipment to rail or barge.

Trucks can go virtually anywhere in the U.S. They are not limited to waterway channels, railroad tracks, or pipelines. This is a major competitive advantage. In some instances it means that trucks are the only practical model of transport.

It should also be noted that because of their role in pickup and delivery, truck costs and the associated terminal costs are often an important part of the cost structure of shipments made on other modes.

2. There are several levels of rail service, each with its own cost (and rate) structure. These range from the Trailer-on-Flat-Car or piggyback service, designed to compete with trucks for small shipments of high value commodities on service as well as price, to the unit train service, which is designed for the low cost movement of bulk commodities.

The costs of shipments by conventional rail car are probably less than by truck for shipments of over 100 to 400 miles, depending on the commodity, but always greater than the costs by water. The unit train concept provides low costs for hauling bulk commodities long distances. Lower costs per ton-mile are available only from pipelines and waterways, both of which are limited to fixed locations. Total unit train costs may be less than waterway costs due to the circuity of the waterway.[1/] In addition, the unit train terminal may be more favorably located so that the collection and terminal costs for barges are enough higher than for rail to give a higher total cost for barges. However, it is doubtful that unit trains can ever have lower costs than an existing pipeline.

Unit trains, then, will be the preferred mode for moving bulk commodities under many conditions. It should be pointed out, however, that unit trains require a tremendous amount of point-to-point volume. In addition, terminal facilities must be adequate to load or unload this volume within a few hours.

3. Waterways have a cost advantage per ton-mile over all modes except pipelines for moving low value bulk commodities. Waterways will generally have a cost advantage over pipelines for moving solid commodities because of the preparation and drying costs associated with piping solids. Waterways do have disadvantages, including the seasonality of northern waterways, circuitry, and a limited number and capacity of terminal facilities.

[1/] Unit train costs might also be less than total waterway costs on <u>specific</u> waterways that have high operation and maintenance costs.

Because of the seasonality factor, good railroads are a necessity to supplement the Upper Mississippi waterway. Circuitry has to be considered in determining total costs, but all modes have some circuitry and some waterway origin-destination pairs are reasonably direct. The location of terminals are important, as the terminal location affects the cost of assembly or distribution. However, for important commodities (grain) going to the Gulf, the cost of the water is probably low enough to absorb additional assembly costs if necessary to get adequate volume.

Studies have indicated that rail rates (as a percentage of costs) are lower in the presence of water competition and higher in its absence. (2, 4) Consequently, barges have a greater influence on the commerce moving through the area than indicated by volume shipped.

4. Pipelines have the lowest cost per ton-mile moved and generally have the least circuitry. However, they require a large initial investment and a large volume of point-to-point movement. Pipelines can be expected in the future to move the liquid bulk commodities for which there is adequate demand and a stable supply, that is, in the long run pipelines will provide petroleum and petroleum products to the Upper Mississippi Valley. In the meantime, until the uncertainty of the location of future supplies is resolved, barges, as the next lowest cost mode, will handle an increasing amount of petroleum shipments. On the other hand, it is unlikely that solid commodities, such as coal or grain, will be moved by pipelines over routes paralleling waterways. The cost advantage is too great.

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CHAPTER VIII

ENERGY AND ENVIRONMENTAL CONSIDERATIONS

Energy Intensiveness

This section will discuss the "energy intensiveness" of the different modes of bulk transportation. The discussion will generally be in terms of BTU's per ton-mile. Table 1 gives the BTU content per gallon of various fuels. Generally speaking, goods should be moved by the transport mode that has a relatively low energy intensiveness, both because of fuel costs and the national policy of energy conservation.

Any discussion of transportation energy should recognize that transportation is a wasteful user of energy. Only about 20 percent of the fuel used by surface transportation produces useable energy to drive vehicles, while 80 percent is wasted as non-recoverable heat. By contrast, large industrial users of energy convert more than 50 percent of their fuel into useful channels.[1/]

Energy intensiveness varies within a mode due to situational factors such as type and condition of equipment, size and shape of load, speed, length of haul, load factors, terrain and other operating conditions. Consequently, a mode of transportation which has a high overall energy intensiveness may under the right conditions be the low energy intensive mode for some segments of traffic and vice versa. An outstanding example of the effect that operating conditions can have on energy requirements even within a mode was the observation of the former of New York Central that

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1/ Industrial Studies of Ground Freight Transportation, p. IX-1.

trains of empty tri-level automobile cars needed more power at high speed than when loaded with automobiles soley because of differences in wind resistence.[2/]

TABLE 1

ENERGY VALUES

Item	BTU's*	Unit of Measure
Propane, Butane and Mixtures	95,500	Gallon
Diesel Fuel (middle distillate)	138,690	Gallon
Residual Fuel Oil	149,690	Gallon
Gasoline	125,071	Gallon
Kerosene	131,000	Gallon
Lubricants	144,405	Gallon
Coal	$26,200 \times 10^3$	Short Ton
Natural Gas	1,032	Cubic Foot
Electrical Energy	3,413	KWH

*BTU - British Thermal Unit, the amount of heat required to raise one pound of water one degree Fahrenheit at or near 39.2 F.

This observation should be kept in mind since most of the reported studies deal in averages. In addition, Harbeson (2) points out that there were important shifts in energy intensiveness differences between modes from 1950 to 1970 so that there are continuing changes in the lowest energy intensive modes. There was a dramatic increase in railroad fuel efficiency in the fifties primarily due to the switch from steam to diesel power. This was due both to increases in the thermal efficiency of diesel engines and the fact that diesels burn fuel more nearly in proportion to train speed and

2/ Ibid., p. 2.

resistence and burn less fuel while idling. (3) Similarly, between 1950 and 1960 waterway operators improved their energy efficiency through larger vessels, bigger tows and more efficient engines. Since 1960, however, in attempting to improve service and vessel turnaround, efforts have been made to increase operating speeds. Since power requirements increase with speed by an exponential factor of about three depending on the waterway, fuel consumption per ton-mile and hence energy intensiveness increased. Recently improved diesel engines, bigger trucks and improved highways have decreased motor carrier energy intensiveness and even more recently unit trains have reduced energy intensiveness in long rail hauls of bulk commodities. However, on the average, energy utilization per ton-mile for both rail and truck has bottomed out and has been slowly increasing due to service demands, competitive factors and environmental controls.[3/]

Besides the fact that due to various speed and operating conditions there frequently will result in an overlapping range of energy intensiveness without one mode being clearly superior, route circuitry must be considered. For instance, one source estimated barge miles to be 1.4 times the most direct rail mileage. To require more energy per trip, the rails would have to use 1.4 times the energy required per barge ton-mile.

Comparison of Energy Intensiveness Studies

There are several recent studies considering the energy intensiveness of the various modes. Although relatively consistent, the results are not conclusive for a number of reasons:

3/ Ibid., p. II-1.

1. Some of the studies purport to be on the energy required in line-haul transportation by the various modes. To the extent that additional pickup, delivery or handling is required, that energy use is not included.

2. Some of the studies attempted to take national transportation statistics and national energy consumption and arrive at measures of energy intensiveness. To the extent that there are problems of enumeration and double counting of traffic and problems of allocating energy consumption to freight and passengers there are, of course, problems of reliability.

3. These studies are expressed in BTU's per ton-mile implying that this is the all inclusive measure of energy intensiveness. No consideration is given to type and quality of fuel used, and the energy consumed in acquiring and transporting such fuels.

4. The unit, ton-miles, (although probably quite reasonable when comparing bulk commodity movements) does not allow for commodity differences requiring different handling, extra care, etc.

5. These studies pertain to energy consumed in transport operations. They do not consider such things as energy consumed in manufacturing the transport equipment, preparing road beds or dredging channels.

6. Within mode, there are wide differences in energy consumption caused by terrain or number and size of locks, type of commodity, etc. In this study we are generally concerned with north-south movement over a relatively favorable terrain.

7. Circuitry is not considered and although the waterways are generally the most circuitous, it occurs in all modes.

Industrial Energy Studies of Ground Freight Transportation, July, 1974, by the firm of Peat, Marwick and Mitchell (3) summarized energy requirements for each mode as shown in Table 2. This study was prepared for the U.S. Department of Commerce to provide the Government with specifics of energy consumption in relatively well defined segments of ground freight transportation. The estimates are a composite of a large number of previous studies and available published data supported by interviews and discussions with representatives of industry.

In this composite ranking, the least energy intensive mode is the unit train followed by inland wat erways and intercity line-haul trains.

Table 3 includes the findings of a number of other recent studies along with the Peat Marwick composite. (These studies were all available to the authors of the Peat Marwick study. Table 3 is completely extracted from the Peat Marwick study.) These studies appear to adequately represent the available data.

From these and similar studies it appears as if waterways are a relatively low energy intensive mode, their only competitors being pipelines and trains. Because of the circuitry factor, pipelines are probably more energy efficient than waterways. Waterways generally have an advantage in energy use over ordinary rail operations although between some origin-destination pairs this advantage would be lost because of the circuitry of the waterway. The only study which explicitly looks at unit trains gives them an advantage over waterways although it should be noted that the energy consumption is based on a 200 car-25mph train. Unit trains of 100 cars are considered large in current grain transportation.

TABLE 2

ESTIMATED RANKING OF ENERGY INTENSIVENESS*

Mode		Approximate BTU Per Net Ton Mile	Factor Rank	Net Ton Miles/Gallon Diesel Fuel	Gallons Diesel Fuel Per 1000 Net Ton Mile	Est. Ratio Gross Ton Miles Per Net Ton Mile
Inland Waterway		500	1.00	277	3.61	1.8
Oil Pipeline		600	1.20	231	4.33	1.0
Railroad:	General	700	1.40	198	5.05	2.5
	30,000 gross ton Unit Train (200 cars @ 25mph)	330	.66	420	2.38	1.7
	Intercity only	500	1.00	277	3.61	2.5
	TOFC	700	1.40	198	5.05	3.0
	Short, Fast Train	1430	2.86	97	10.31	2.7
Truck:	General	2800	5.60	50	20.00	2.2
	Intercity only	1900	3.80	73	13.70	2.0
	Local only	7000	14.00	20	50.00	3.0
Air Freight		42,000	84.00	3.2	312.5	n.a.

*Due to different nature of freight, length of haul, and circuity between modes, modal comparisons are not entirely appropriate.

Source: Industrial Studies of Ground Freight Transportation.

TABLE 3

VARIATIONS IN ENERGY INTENSIVENESS BY MODE
BTU'S PER NET TON-MILE

Freight	Peat, Marwich, Mitchell "Industrial Energy Studies of Ground Freight Transportation	Rand Corp. "Methods for Est. Vol. Energy and Demand of Freight Trans."	Batelle Labs "Energy Req'd. for Movement of Intercity Freight"		Oak Ridge Nat'l Labs (Hirst)	Reebie & Assoc.	Carnegie-Mellon U.	DOT
			Emmissions Analysis Basis	Fuel-Use Basis				
Inland Waterway:								
General	500	500			680		578	463
60,000 Ton Tow (Lower Mississippi)							630	
Oil Pipelines	600	1,850			450		519	
Railroad:								
30,000 Gross Ton Unit Train (200 cars) @ 25 mph	330						330	
3,000 Gross Ton Train (40 cars) @ 90 mph	1,430						1,430	
Total Freight	700	750		680	670			771
Intercity	500		475[2]	500				
Trucking:								
Total Freight	2,800	2,400		2,800	2,800			2,774
Intercity	1,900		1,730[2]	1,870				
Local Urban Trucking	7,000						6,935	
Air Freight	42,000	63,000			42,000		13,500[3]	
Trailers for TOFC Use						603[1]	816[4]	
Freight Locomotives						544	693	
Tractor Units:								
Gas								
Diesel						1,812		
Diesel 250 HP @ 50 mph							2,773	

1/ Includes 10 miles of dragage
2/ Excludes fuel spillage and wasteage
3/ Kerosene @ 135,000 BTU/gal.
4/ Weight of trailers excluded.

Source: Industrial Studies of Ground Freight Transportation.

Quantity-Distance Tradeoffs

The preceding section was concerned with energy efficiency or intensiveness of the various modes in long line-haul operation. The USRA Preliminary System Plan (4) discussed the energy tradeoffs for rail and truck in short-low volume operations, i.e., pickup, assembly, delivery, etc. This is of particular interest with respect to grain, most of which is transported from the farms to rail or barge terminals. The study says "Rail-truck transfer results in lower total resource consumption than rail for branch lines longer than 7 miles with 5 loaded cars per day or branch lines 50 miles long with 18 cars or less per day.

Type of Energy Required

Water, rail and truck movements all use petroleum products, primarily diesel fuel, as their energy source. Since petroleum conservation is a critical aspect of our energy program, it is assumed desirable to transfer as much energy consumption as possible to other sources. The USRA Preliminary System plan (4) discusses this briefly and concludes that rail is the only mode for which substitution for petroleum is possible. This would be via electrification of the main lines of the railroads. However, this would cost $125,000 to $200,000 per route mile and take 3-5 years. This cost does not include the construction of necessary power generation stations and the transmission facilities. It is doubtful that either the railroads or the utilities will have the capital to undertake such an enormous investment.

General Motors has announced an all electric locomotive and expects to announce another larger model next year. However, a GM spokesman said, "no case can be made to support a major electrification investment (by a railroad) at this time on a purely economic basis. "..." seems unlikely that any large-scale electrification will take place in the near future without massive government participation."[1/]

Air Pollution

Generally energy consumption and air pollution output are directly proportional. For practical purposes the mode that minimizes energy consumption will minimize air pollution.

Implications of Higher Energy Prices

There are at least three considerations when investigating the effects of higher energy prices on bulk transportation.

a. The costs (and relative costs) of fuel consumed in each transport mode and their effect on the mode's total cost.

b. The change in demand for a fuel due to price changes and the subsequent change in transport requirements for that fuel.

c. The effect of energy cost changes on the cost of production of various commodities and the subsequent effect on the supplies of the commodities entering commerce and requiring transportation.

The uncertainties surrounding the far reaching changes in the amounts and kinds of energy to be transported (point b above) are discussed at length in other sections. Point c above is beyond the scope of this study.

However, Fedeler, et. al. (5), discuss the point "a" stating out that trucks, locomotives, towboats and ships all burn petroleum fuels. In 1972, the representative price of diesel fuel in the Midwest was 11 cents a gallon. It rose to nearly 31 cents a gallon by July 1974. Truck diesel fuel (including

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1/ The Wall Street Journal, May 2, 1975.

taxes) from service stations increased from 27 cents in 1972 to 47 cents in July 1974. This represents a 74 percent increase in fuel costs for trucks and a 182 percent increase for railroads and barges. Rails and barges had a lower 1972 cost because they are large quantity users and don't pay highway fuel taxes.

In Fedeler, et. al.'s analysis fuel represents a greater percentage of total costs for long than short distances and is greater for truck than barge and greater for barge than rail. Table 4 is from Fedeler, et. al., and shows striking changes in fuel costs as a percent of total costs for hauling grain. Although it takes less fuel per ton-mile by barge than rail, rail fuel costs are a smaller proportion of total costs. Consequently, the percentage increase in costs for barges is greater than that for rail. Fedeler, et. al.'s computations indicated that the increased fuel costs increased truck and barge transportation costs 15-18 percent and rail costs 4-10 percent depending on the length of the trip.

The net effect is that railroads costs become more competitive with respect to truck and barge costs as fuel costs increase. This implies an increase in rail traffic at the expense of trucks and barge traffic.

Environmental Concerns

All human activities affect the environment. The magnitude of the environmental consequences depends both on the aggregate amount of human activity (which is a function of population, population density, and per capita consumption) and on the type of activity. There is no denying that transportation activities in the U.S. have major environmental effects, if only because of their importance in the economy and the amount of resources used.

TABLE 4

Table 6.1. Effect and significance of increased fuel prices on select heavy grain transportation costs.

	Total fuel cost		Total shipping cost		Fuel as a percent of total cost	
	low fuel price[b]	high fuel price[c]	low fuel price	high fuel price	low fuel price	high fuel price
Truck[a] (24 tons, 100 miles)	10.80	18.80	51.53	59.53	20.96	31.58
Rail (97.5 tons 100 miles)	4.29	12.09	178.57	186.37	2.40	6.49
Truck (24 tons, 1000 miles)	108.00	188.00	456.82	536.82	23.64	35.02
Rail (97.5 tons, 1000 miles)	42.9	120.90	786.34	864.34	5.46	13.99
Barge (1400 tons, 1302 miles)	519.84	1465.01	5147.76	6092.93	10.10	24.04

[a]Distances are one-way, but costs are for round trips.

[b]The low fuel price is 27 cents a gallon for trucks and 11 cents a gallon for rail and barge.

[c]The high fuel price is 47 cents a gallon for trucks and is 31 cents a gallon for rail and barge.

Source: Fedeler, et. al. (5).

For example, in 1973 freight and common carrier passenger transportation accounted for 12 percent of all energy consumed in the U.S. (All transportation accounted for 31 percent.) Transport facilities, including highways, roads and streets, airports, railroad yards and port facilities, occupy 1.5 percent of American land area.[1/]

Since it is necessary to carry on transportation activity, two important considerations in assessing the seriousness of environmental effects are: (1) how close to population centers the particular event occurs and (2) whether or not it is irreversible. That is, will large numbers of people be affected and/or will the result be permanent.

Environmental consequences of transportation activity include (but are not limited to):

- Air pollution
- Reduction in water quality
- Oil spills
- Noise pollution
- Space requirements for rights-of-way and terminals
- Right-of-way impact on adjacent area
  - visual
  - erosion
  - drainage

Although we customarily associate just one or two transportation modes with each element of the above list, all modes have most of these environmental effects. However, the effects vary in seriousness because of degree and where the effect takes place.

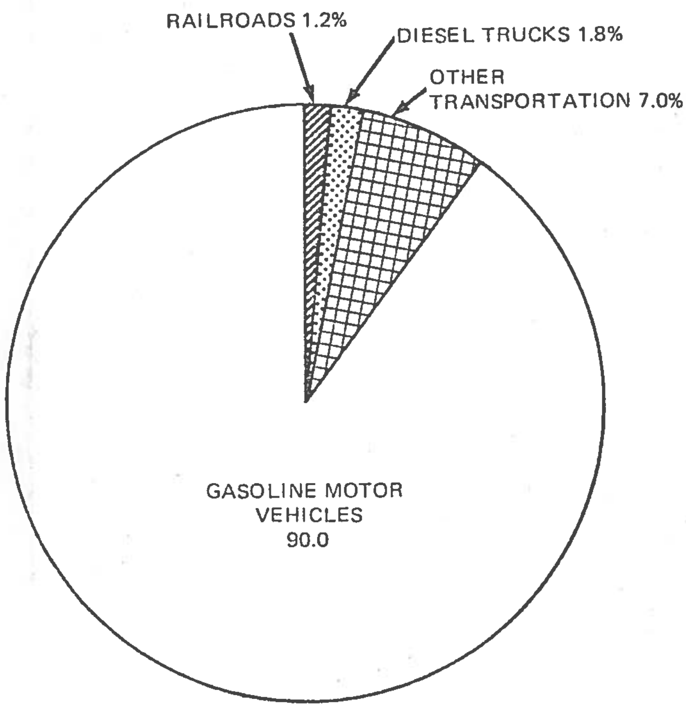
1/ Preliminary System Plan, p. 146.

Air Pollution

Air pollution varies by mode, but bulk commodity transportation modes are generally not major contributors to the problem (see Figure 1). Furthermore, most of the air pollution generated in moving bulk commodities does not occur in cities. Rather, it occurs, for the most part, in relatively lightly populated areas and away from areas with major air pollution problems according to the Preliminary System Plan (4).

Air pollution from diesel engines is directly related to fuel consumption. Trucks product about 4 times as many pollutants per ton-mile as rail in mainline service and about 4.8 times those per waterway ton-mile. The four-stroke railroad engines used in branch line operations are particularly high in pollution emissions. Federal standards call for the reduction in air pollutant emissions from new diesel engines, which will temper the adverse environmental impact of increasing transportation requirements.

FIGURE 1
PERCENT OF AIR POLLUTANT EMISSIONS FROM ALL TRANSPORTATION SOURCES – 1968



SOURCE: BATTELLE COLUMBUS LABORATORIES, A STUDY OF THE ENVIRONMENTAL IMPACT OF PROJECTED INCREASES IN INTERCITY FREIGHT TRAFFIC TO ASSOCIATION OF AMERICAN RAILROADS, AUGUST 1971, p. 18

Water Quality

The various modes affect ground and surface water quality in a variety of ways. For instance, the Final Environmental Impact Statement (1) discusses positive as well as negative effects on surface water as a result of the lock and dam system of the Upper Mississippi. The positive effects are, of course, generally associated with the regulation of the water level and not due to barge traffic. Negative effects on surface water quality include pollution from bilge water, oil spills, other material spills and turbidity resulting from prop wash. It should be noted that non-commercial as well as commercial traffic is a source of these same pollutants.

Water quality can be affected by railroad operations as well. According to the Preliminary System Plan (4), sources of pollution due to railroad operations include accidental spills, train wrecks, herbicide use, drainage disruption, and the leakage of oil and lubricating fluids. The seriousness of the situation is dependent upon the ground water level, proximity to water surface seepage, and the biodegradability of the foreign substances. Railroad causeways can interfere with normal water flow, thus affecting marshes and other ecologically sensitive areas. Such artifical impoundment of water could lead to atrophication and degradation of water quality.

The wide application of herbicides to railroad rights-of-way for weed and brush control is a serious threat to water quality, as application of herbicides is not uniform. It is a function of the terrain and vegetation. Loadings per acre are generally determined by the manufacturer's specifications, and the potential runoff of chemicals into surface water is unknown.

Motor traffic and the highway system have similar effects on ground water because of changes in terrain, the potential for spills, etc.

Oil Spills

The potential for oil spills exists whenever oil is transported. Oil spills from ruptures are perhaps the greatest environmental threat posed by an in-place pipeline, with possible damage to land, surface water and wildlife.

Of the other modes, barge shipments of petroleum present the possibility of larger scale spills because of the larger quantities in a barge. There is greater potential for difficulty in containing a barge spill and localizing its effects because of its location on the water.

Visual Considerations

Visual blight and related aesthetic considerations can be impacted by transportation modes in two ways. First is the visual appearance of the right-of-way, its harmony with the surrounding area. Second is the visual impact of the necessary terminals and other industry which by desire or necessity locate next to the transport way, both upon people who have to live in the area and those who pass by. Because of the general irreversibility of visual blight (industry cannot afford to move once located, and an industrialized site is almost impossible to return to its natural condition), exceptional deliberation and caution should be taken in locating terminals and industry in or near scenic areas.

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CHAPTER IX

HISTORICAL BULK COMMODITY MOVEMENTS AND PRODUCTION

Data on commodity movement by mode is surprisingly incomplete. It is very difficult to compare the information that is available concerning the various modes. We are concerned with four transportation modes: barge, rail, truck, and pipelines. These systems differ significantly from each other.

Information is available giving historic volume by mode and the percentage each mode has of total U.S. commodity movement. Table 1 shows the modal shares of total intercity transportation in the U.S. for the years 1939 to 1973.

However, we are specifically concerned with the St. Paul District of the Army Corps of Engineers and with movements of particular bulk commodities. More specific information of this nature is not complete.

The most useful data available concern barge traffic. Good information is available on the movement of commodities by barge above Locks and Dam 2 on the Mississippi River System (11). Information is incomplete, however, concerning traffic between Locks and Dam 2 and Locks and Dam 10.

The St. Paul District of the Army Corps of Engineers keeps records of traffic moving through various locks in the district (10). This information involves a summary of estimates supplied by lockmasters. This information seemed to vary substantially from figures presented in Waterborne Commerce of the U.S. The statistics in Waterborne Commerce are a summary of the figures supplied by shippers, as required by law. The information provided by the District in NCS Form 302s is inadequate to allow a determination of commodity movement by barge below Locks and Dam 2.

Table 1

INTERCITY FREIGHT BY MODES

(Billions of Ton-Miles)

Year (1)	Rail Amount (2)	Percent (3)	Truck Amount (4)	Percent (5)	Oil Pipeline Amount (6)	Percent (7)	Great Lakes Amount (8)	Percent (9)	Rivers & Canals Amount (10)	Percent (11)	Air Amount (12)	Percent (13)	Total (14)
1939	339	62.3	53	9.7	56	10.3	76	14.0	20	3.7	.01	00	544
1940	379	61.3	62	10.0	59	9.5	96	15.5	22	3.6	.02	00	618
1941	482	62.4	81	10.5	68	8.8	114	14.8	27	3.5	.02	00	772
1942	645	69.5	60	6.5	75	8.1	122	13.1	26	2.8	.04	00	928
1943	735	71.3	57	5.5	98	9.5	115	11.2	26	2.5	.05	00	1,031
1944	747	68.7	58	5.3	133	12.2	119	10.9	31	2.8	.07	.01	1,088
1945	691	67.2	67	6.5	127	12.4	113	11.0	30	2.9	.09	.01	1,028
1946	602	66.6	82	9.1	96	10.6	96	10.6	28	3.1	.08	.01	904
1947	665	65.3	102	10.0	105	10.3	112	11.0	35	3.4	.11	.01	1,019
1948	647	61.9	116	11.1	120	11.5	119	11.4	43	4.1	.15	.01	1,045
1949	535	58.3	127	13.8	115	12.5	98	10.7	42	4.6	.20	.02	917
1950	597	56.2	173	16.3	129	12.1	112	10.5	52	4.9	.30	.03	1,063
1951	655	55.6	188	16.0	152	12.9	120	10.2	62	5.3	.34	.03	1,177
1952	623	54.4	195	17.0	158	13.8	105	9.2	64	5.6	.34	.03	1,145
1953	614	51.0	217	18.0	170	14.1	127	10.6	75	6.2	.37	.03	1,203
1954	557	49.6	213	19.0	179	15.9	91	8.1	83	7.4	.38	.03	1,123
1955	631	49.5	223	17.5	203	15.9	119	9.3	98	7.7	.49	.04	1,274
1956	656	48.4	249	18.4	230	17.0	111	8.2	109	8.0	.58	.04	1,356
1957	626	46.9	254	19.0	223	16.7	117	8.8	115	8.6	.68	.05	1,336
1958	559	46.0	256	21.1	211	17.4	80	6.6	109	9.0	.70	.05	1,216
1959	582	45.3	279	21.7	227	17.7	80	6.2	117	9.1	.80	.06	1,286
1960	579	44.1	285	21.8	229	17.4	99	7.5	121	9.2	.89	.07	1,314
1961	570	43.5	296	22.7	233	17.8	87(67)*	6.6	123(84)	9.4	1.01	.08	1,310
1962	600	43.8	309	22.5	238	17.3	90(66)	6.6	133(90)	9.7	1.30	.09	1,371
1963	629	43.3	336	23.1	253	17.4	95(68)	6.5	139(94)	9.6	1.30	.09	1,453
1964	666	43.2	356	23.1	269	17.4	106(73)	6.9	144(102)	9.3	1.50	.10	1,543
1965	709	43.3	359	21.9	306	18.7	110(76)	6.7	152(110)	9.3	1.91	.12	1,638
1966	751	43.0	381	21.8	333	19.1	116(81)	6.6	164(117)	9.4	2.25	.13	1,747
1967	731	41.4	389	22.0	361	20.5	107(75)	6.1	174(128)	9.9	2.59	.15	1,765
1968	757	4.12	396	21.5	391	21.3	112(75)	6.1	179(139)	9.7	2.90	.16	1,838
1969	772	40.8	404	21.3	411	21.7	115(83)	6.1	188(144)	9.9	3.20	.17	1,895
1970	768	39.7	412	21.3	431	22.3	114(79)	6.0	205(156)	10.6	3.40	.18	1,933
1971	746	38.2	445	22.8	444	22.9	105(70)	5.4	210(161)	10.7	3.50	.18	1,954
1972	784r	37.7r	470	22.7r	476r	23.0r	109(73)	5.3	230(178)	11.1r	3.70r	.18	2,073r
1973(p)	854	38.6	510	23.0	495	22.4	114	5.1	237	10.7	4.20	.19	2,214

* Figures in parentheses are based on different reporting techniques. (p) Preliminary TAA estimate.

r Revised as shown in Quarterly Supplement, Transportation Facts & Trends, January 1974.

Source: Transportation Facts and Trends, October, 1973, as published in Simat, Helliensen and Eichner, Inc. Competition in the Railroad Industry, February, 1975.

The information available on barge traffic in the St. Paul District does little to define origins and destinations of shipments. Statistics on ton-mile movements of specific commodities is not available.

For the purposes of this study the examination of rail transportation is a more complex problem. The rail system itself is much more complicated than the river system. It is even difficult to define what elements of the rail system should be included in the study.

Generally, the information that is available is gross data involving the entire U.S., as in Table 1, or large regions of the country (3, 13). There appears to be no complete data source available on rail traffic that directly competes with or feeds barge transport in the St. Paul District.

Further research will be needed to obtain complete information on volume commodity flows by rail. A likely approach would be to choose origins and destinations that would be representative of major flows of the various bulk commodities. There is some question as to the availability of detailed information on such flows. Cooperation from railroad companies and shippers would likely be necessary if such an approach were taken.

Truck transportation of bulk commodities is even more difficult to determine than that of rail. Very little information is available on this movement. Additional research is needed to obtain shipping patterns of truck transport and volumes being shipped. Further study is also needed to determine how this movement affects barge transportation.

There is some information available on the volume of petroleum products that enter Minnesota by pipeline , but the data is general, non-specific and incomple

GRAIN

Rather extensive information is available on the movement of grain into and out of both the Minneapolis-St. Paul and the Duluth-Superior areas (4, 11). Obtaining information on grain movements in other parts of the state is considerably more difficult.

Barge Movement

Grain, which dominates outbound shipments, leads all commodity groups in barge movements in the St. Paul District. Essentially, all of this grain moves to Gulf ports for export. The Army Corps of Engineers presents an annual summary of volume movement, by commodity, on the inland waterway system (11). This report gives a good summary of the volume of grain moving down the Mississippi from ports north of Locks and Dam 2. With the exception of that flowing out of the Black River, the report does not delineate the grain generated at ports between Locks and Dam 2 and Guttenberg, Iowa. Table 2 shows the barge movement of grain for the years 1970-1973. This involves grain leaving ports in Minneapolis and St. Paul, as well as on the Minnesota and Black Rivers. The table indicates that the principal grains leaving these ports are corn, wheat, soybeans, and oats.

Total volume shipped by barge showed increases in 1972 and 1973, which were both heavy export years. The distribution of total volume among the grains shifted from year to year. There has been a steady decline in the volume of soybeans shipped and an increase in shipments of corn and wheat in recent years.

Table 2

Barge Shipments of Selected Grains from Ports of Minneapolis and St. Paul on the Mississippi River, and Ports on the Minnesota and Black Rivers (in tons)

Commodity / Year	1970	1971	1972	1973
Barley & Rye	43,926	49,825	316,058	37,524
Corn	2,021,186	1,796,832	2,028,388	3,495,807
Oats	351,564	539,848	649,565	258,376
Sorgum Grains	-	-	-	38,143
Wheat	966,928	982,100	1,242,059	1,024,150
Soybeans	1,023,976	677,108	613,403	582,817
Total	4,407,580	4,045,713	4,844,564	5,436,808

Source: United States Army, Corps of Engineers, Waterborne Commerce of the United States. (1970-1973)

The Minneapolis Grain Exchange also keeps records on the volume of grain shipped by barge from Twin Cities area elevators (4). Table 3 shows barge shipments, as reported by the Grain Exchange for the years

Table 3

Barge Shipments of Grain by Minneapolis-St. Paul Area Elevators As Reported to the Minneapolis Grain Exchange (in tons)

Commodity / Year	1970	1971	1972	1973
Barley	12,720	13,752	249,192	-
Rye	14,336	41,692	41,692	33,152
Corn	2,011,044	1,734,040	2,157,120	3,510,528
Oats	361,008	543,072	664,000	233,984
Wheat	979,110	967,080	1,302,810	1,017,360
Soybeans	1,052,790	676,260	707,308	581,490
Total	4,431,008	3,975,896	5,122,290	5,376,514

Source: Minneapolis Grain Exchange, Annual Reports (1970-1973)

1970-1973.

As might be expected, since the reports cover different ports, there are some differences between the Corps of Engineers estimates and those of the Grain Exchange. In general, however, the two match quite closely. Both reports give adequate information on barge grain movements out of the Twin Cities area.

That stretch of the River between the Twin Cities and Guttenberg is much more of a problem. All indications are that there is a considerable volume of south-bound grain generated in this stretch.

Rail Movement

Rail movement of grain out of the state is more difficult to determine. There is more information available for grain leaving Minneapolis-St. Paul and Duluth-Superior than other areas of the state. The Annual Reports of the Minneapolis Grain Exchange include information on grain leaving these areas. Table 4 shows the volume of grain that left Minneapolis-St.

Table 4

Rail Shipments of Grain from Minneapolis-St. Paul Area Elevators
Reported by Western Weighing and Railroad Inspection Bureau (in tons)

Commodity / Year	1970	1971	1972	1973
Barley	1,569,828	1,507,728	1,711,944	1,637,856
Rye	114,862	92,092	84,644	339,416
Corn	1,195,690	607,348	360,052	1,245,244
Oats	502,445	426,000	475,000	866,832
Wheat	1,395,498	982,410	929,670	1,532,130
Soybeans	268,008	123,420	16,770	61,770
Flax	13,090	27,440	96,068	39,340
Total	5,059,421	3,766,438	3,674,556	5,722,588

Source: Minneapolis Grain Exchange, Annual Reports (1970-1973)

Paul area elevators by rail for the years 1970-1973. This includes all carloads of grain that were inspected by the Western Weighing and Railroad Inspection Bureau. They inspect every carload of grain that leaves the Twin Cities area whether it is destined out of state or for other locations in state. This becomes a problem if we want to analyze intermodal competition for transportation. Barge grain movement out of the St. Paul District is all long haul movement. The extent to which short haul movement by truck or rail competes directly with barge does not appear to be available in the literature.

Elevators with multiple rail-car loading facilities are becoming an increasingly important origin of rail grain leaving Minnesota. Unit trains loaded out of these elevators for Gulf ports compete directly with rail-barge and truck-barge movements to the Gulf. Data are available summarizing rail shipment from southern Minnesota for the 1973 crop year (2). Table 5 shows the volume and destinations of grain shipped from these multiple-car loading facilities. The table includes shipments by both truck and rail.

This data is very good for a one year period. It is important to note, however, that the mode of shipment to the Gulf is very dependent upon relative rates between modes. The year included in this study was one of particularly high export demand. Barge rates were very high because of the high demand for barges. Rail rates were therefore relatively more favorable than has been the case more recently.

Multiple-car loading facilities are a new innovation. Multiple-car

Table 5

Summary of Grain Shipped by Southern Minnesota Elevators with Multiple-Car Loading Facilities, July 1, 1973-June 30, 1974

Table 1. Volume of grain shipped by 19 southern Minnesota country elevators with multiple-car loading facilities, July 1, 1973-June 30, 1974.

	Method of shipment			
	Rail		Truck	
Type of grain	Million bushels	Percent	Million bushels	Percent
Corn	43.2	90	4.8	10
Soybeans	8.1	63	4.7	37
Small grain	.2	25	.6	75
Total	51.5	84	10.1	16

Table 2. Major destinations of grain shipped by rail from 19 southern Minnesota country elevators with multiple-car loading facilities, July 1, 1973-June 30, 1974.

	Corn		Soybeans	
Destination	1000 bushels	Percent	1000 bushels	Percent
Gulf Ports	26,023	60.2	6,298	78.7
Duluth-Superior	11,776	27.2	225	2.8
Mpls.-St. Paul	1,544	3.6	154	2.0
Chicago	2,565	5.9	315	3.9
Mankato	—	—	898	11.2
Other	1,331	3.1	114	1.4
Total	43,239	100	8,004	100

Table 3. Major destinations of grain shipped by truck from 19 southern Minnesota country elevators with multiple-car loading facilities, July 1, 1973-June 30, 1974.

	Corn		Soybeans	
Destination	1000 bushels	Percent	1000 bushels	Percent
Savage	2,858	59.6	221	4.7
Red Wing-Winona	885	18.4	180	3.8
Mpls.-St. Paul	74	1.5	54	1.1
Mankato	—	—	3,211	68.1
Iowa processors	—	—	925	19.6
Local feeders	960	20	—	—
Others	20	0.4	121	2.6
Total	4,797	100	4,712	100

Source: Dahl, Reynold and Michael Martin, Minnesota Agricultural Economist, "Multiple-Car Rail Rates -- Their Impact on Grain Transport," No. 563, January 1975.

rail rates were offered for the first time in southern Minnesota in 1972. For this reason alone it is difficult to ascertain the impact of multiple-car shipping on intermodal competition. Information is only available for the 1973 crop year, and great care must be taken in drawing conclusions from these data.

The only other origin for which information on rail shipments is available is Duluth-Superior (4). Rail shipments out of this area in general occur only to move grain that for some reason (e. g. strikes, weather) cannot be shipped out by vessel. Train shipment of grain from these ports would not appear to compete directly with the River for grain movement.

Vessel Movement

The Lake ports do compete directly with the River for grain to load out on vessels. Information is available from both the Army Corps of Engineers (12) and the Minneapolis Grain Exchange (4) on grain moving out of Duluth-Superior by vessel. Table 6 summarizes these movements for the years 1944-1973. It is readily apparent from the table that there have been significant year to year variations in the volumes of the various commodities shipped and in the total amount of grain leaving the ports. However, the overall trend seems to have been a steadily increasing volume of grain shipped from Duluth-Superior.

The majority of grain shipped from Duluth-Superior ports is exported. Table 6 indicates that the percentage of shipments being exported is also increasing. Wheat is the primary grain shipped from these ports,

Table 6

Lake Shipments of Grain and Flax Seed from Duluth-Superior, 1944-1973

(in bushels)

	Total Wheat	Corn	Oats	Rye	Barley	Flax Seed	Soy Beans	Total
1973	172,187,000	49,131,000	41,365,000	22,224,000	57,627,000	161,000	2,503,000	345,198,000
1972	119,407,000	17,478,000	5,955,000	6,882,000	45,867,000	9,597,000	1,541,000	206,727,000
1971	93,248,000	35,893,000	5,836,000	5,953,000	26,854,000	682,000	12,520,000	180,986,000
1970	98,287,000	28,875,000	31,201,000	1,186,000	55,266,000	2,944,000	12,273,000	230,032,000
1969	88,662,000	22,581,000	5,286,000	1,649,000	9,711,000	7,870,000	4,973,000	140,732,000
1968	89,281,000	18,288,000	8,248,000	2,397,000	11,041,000	9,891,000	3,487,000	142,633,000
1967	95,636,000	22,614,000	19,047,000	2,580,000	23,576,000	7,443,000	4,749,000	175,645,000
1966	100,556,000	34,778,000	34,868,000	3,973,000	29,878,000	8,135,000	11,358,000	223,546,000
1965	67,532,000	32,563,000	29,726,000	1,488,000	34,768,000	4,999,000	17,339,000	188,415,000
1964	53,185,000	33,088,000	8,183,000	3,218,000	35,579,000	7,757,000	13,762,000	154,772,000
1963	79,530,000	27,760,000	13,522,000	9,460,000	31,040,000	4,426,000	7,035,000	172,773,000
1962	66,404,000	24,943,000	28,627,000	9,411,000	34,526,000	5,534,000	3,860,000	173,305,000
1961	94,342,000	19,242,000	20,999,000	3,262,000	14,852,000	4,596,000	4,710,000	162,003,000
1960	66,475,000	19,760,000	30,968,000	3,808,000	29,032,000	4,365,000	12,293,000	166,701,000
1959	63,070,640	14,312,365	34,134,890	661,890	27,873,315	8,940,100	279,455	149,272,655
1958	59,199,710	9,387,375	9,854,945	2,160,655	12,072,600	5,724,930	168,215	98,568,430
1957	61,806,545	2,500,775	5,822,360	2,429,995	18,422,220	12,745,105	–	103,727,000
1956	82,241,465	108,950	10,732,450	6,649,570	18,190,990	7,730,590	741,255	126,395,270
1955	66,019,885	4,497,800	5,731,500	1,814,210	23,472,075	9,073,940	–	110,609,410
1954	68,664,665	19,866,060	4,282,585	943,400	7,521,635	14,597,995	–	115,876,340
1953	59,326,710	15,041,475	–	–	2,361,390	3,910,780	–	80,640,355
1952	69,445,215	3,972,895	198,000	–	5,985,680	3,225,620	–	82,827,410
1951	108,732,025	6,310,600	2,663,380	416,570	3,003,780	6,894,290	–	128,020,645
1950	51,905,435	19,037,285	3,354,455	261,130	4,873,895	8,553,845	–	87,986,045
1949	100,521,700	14,866,760	11,390,450	709,610	11,046,590	4,515,755	–	143,050,865
1948	84,846,310	9,307,920	5,630,895	283,130	3,561,630	10,505,330	–	114,135,215
1947	83,353,695	3,868,700	9,667,240	–	6,682,040	4,243,935	–	107,815,610
1946	96,159,385	–	11,945,400	–	2,961,960	5,190,955	–	116,257,700
1945	137,200,780	3,733,750	17,946,505	–	4,935,145	5,675,105	–	169,491,285
1944	108,031,615	354,465	1,831,100	80,000	492,465	4,681,845	–	115,471,490

Source: Minneapolis Grain Exchange, Ninety-First Annual Report. (pp. 53).

accounting for over half the tonnage. The major destinations for these shipments have been the export market and processors in the Buffalo, New York area. (See Figure 1)

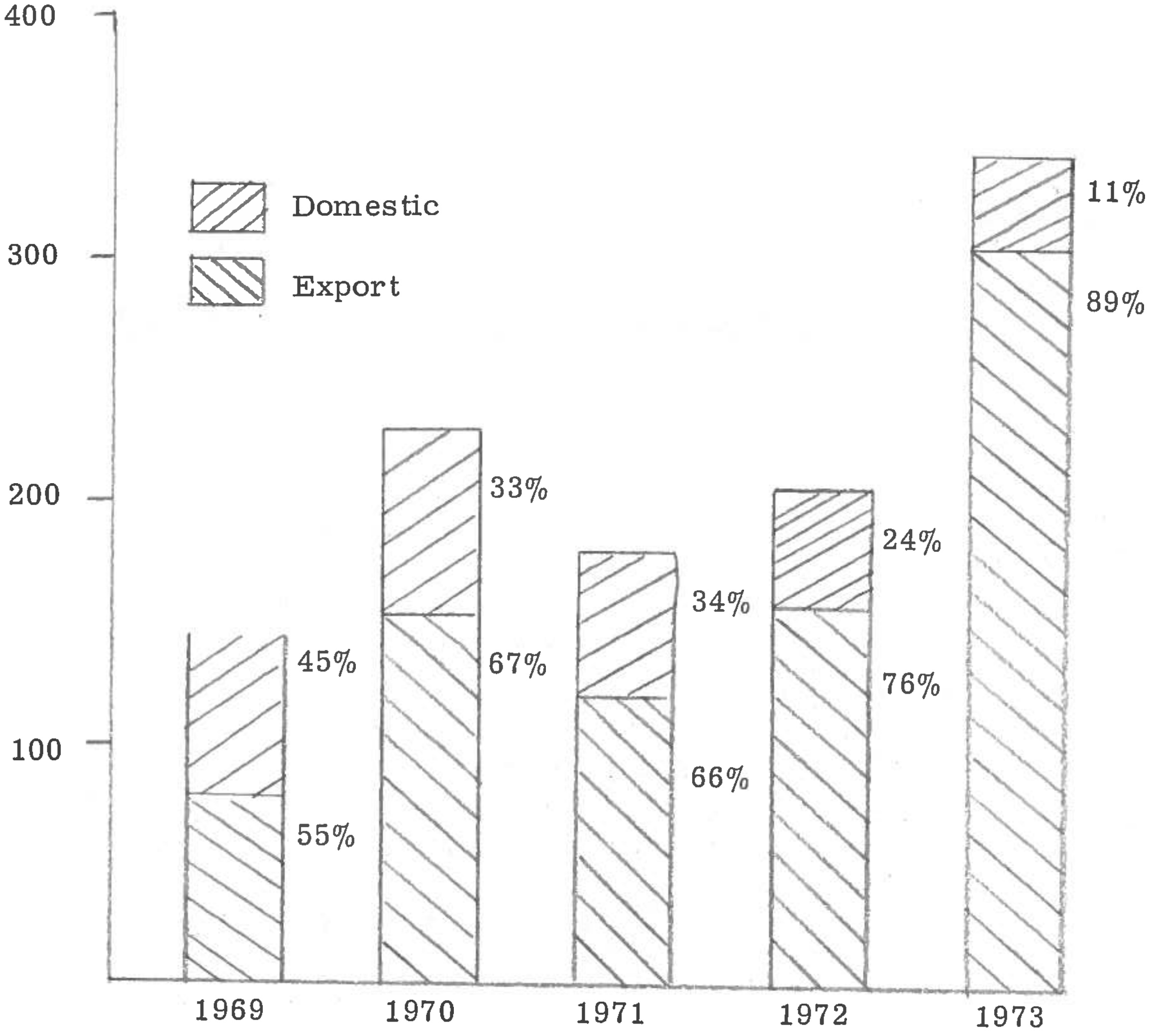
Grain Movement Within Minnesota

Grain moving out of the state for export leaves mainly from the Twin Cities, Duluth-Superior, and terminals and subterminals in the southern part of the state. We are therefore interested in: 1) rail and truck grain transshipped to vessels through Duluth-Superior, 2) rail and truck grain transshipped to barge and rail through the Twin Cities and other river ports, and 3) truck grain transshipped through multiple-car loading facilities in the southern part of the state.

Published data on historical movements through these channels is incomplete. A 1975 report by the Minnesota State Planning Agency studies grain shipping patterns within the state for 1972 (5). A questionnaire was sent to 20 percent of the elevators in the state. The responding elevators represented a 15 percent survey of elevators in the state. Estimates were made on grain movements in the state, as a whole, by extrapolation from the sample data. Figure 2 shows the principal destinations of intra-state grain movements taken from the State Planning report. The Twin Cities appear to be the major destination with almost equal shares arriving by truck and rail. Duluth is the second leading destination. The study includes a series of figures showing the volume of grain, by mode, moving from Minnesota's development regions to major receiving centers. The figures indicate a rather significant truck movement of grain to Red Wing and Winona, which are major transshipment points for barge grain. They also

Figure 1

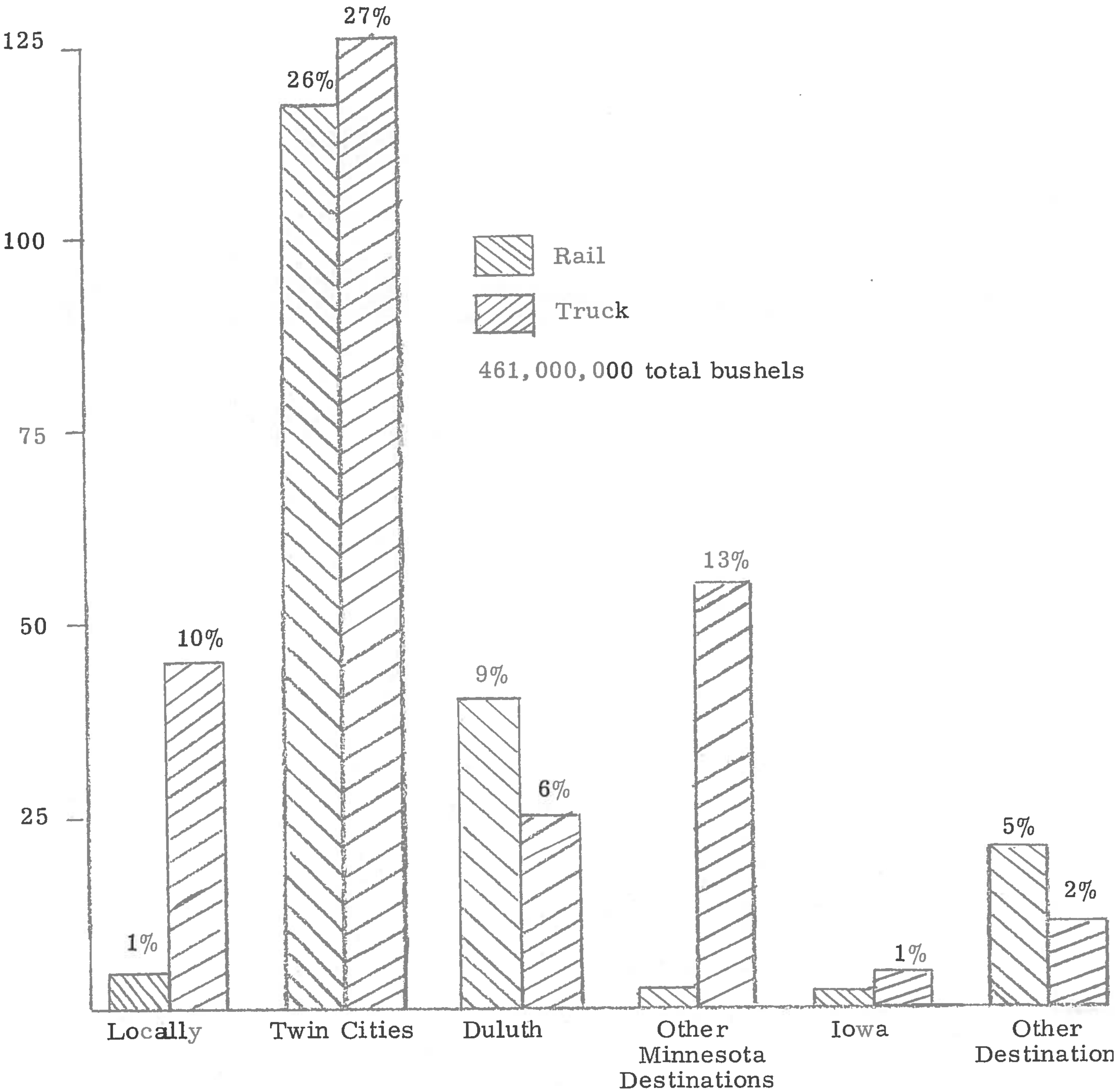
Grain Shipped from Duluth-Superior Ports for Export 1969-1973 (Millions of Bushels)



Source: Minneapolis Grain Exchange, Annual Report of the Minneapolis Grain Exchange, 1969-1973, as presented in: Minnesota State Planning Grain Transportation in Minnesota, p. 66.

Figure 2

Grain Shipments in Minnesota
(Millions of Bushels)



Source: Minnesota State Planning Agency, Grain Transportation in Minnesota.

indicate rail movements out of the southern part of the state for Gulf ports. It should be remembered that the 1972 crop year was only the first year in which multiple-car rail rates were available to southern Minnesota elevators. More grain might be expected to have moved to the Gulf through these types of facilities in later years.

A large volume of grain moves into both Minneapolis-St. Paul and Duluth-Superior elevators from North and South Dakota. The Upper Great Plains Transportation Institute has summarized the movement of North Dakota grain into these two areas, by mode (9). They broke these movements down according to crop reporting districts. Table 7 shows the movement of primary grains from North Dakota to Minnesota terminals in the crop years 1968-1973. Their information came from the North Dakota Public Service Commission's "Grain Movement Report."

Table 7

Volume Shipments of Hard Red Spring, Durum and Barley to Duluth-Superior and Minneapolis-St. Paul by Rail and Truck from North Dakota, 1967-68 through 1972-73
(bushels in thousands)

	Duluth-Superior						Minneapolis-St. Paul					
Crop Year	Hard Red Spring		Durum		Barley		Hard Red Spring		Durum		Barley	
	Rail	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail	Tr[illegible]
1967-68	21,785	12,571	10,496	12,992	3,147	5,200	33,829	10,164	24,216	2,490	45,533	1,[illegible]
1968-69	22,408	20,683	18,558	14,469	6,309	4,691	35,807	10,752	34,087	961	36,118	[illegible]
1969-70	18,659	22,023	12,299	14,821	3,801	3,987	40,359	15,967	26,958	1,073	51,631	[illegible]
1970-71	19,280	24,124	10,612	19,286	4,246	14,939	27,543	16,177	21,828	2,156	39,759	1,[illegible]
1971-72	44,300	25,951	30,291	12,958	3,651	9,837	30,801	18,050	18,793	2,190	42,215	1,[illegible]
1972-73	80,411	15,323	50,133	7,917	4,582	19,032	46,232	14,504	16,280	968	40,179	2,[illegible]

Source: Upper Great Plains Transportation Institute, Rail and Truck Competition in the Transportation of North Dakota Grain.

Minneapolis-St. Paul area elevators and processors compete with Duluth-Superior elevators for North Dakota grain. The importance of these two outlets to North Dakota farmers can be seen in the following quote: "The two markets Duluth-Superior and Minneapolis-St. Paul have traditionally received over 85 percent of North Dakota hard red spring, durum, and barley shipments. In addition, roughly 85 percent of all grain shipments from North Dakota to all markets is composed of hard red spring, durum and barley grains....."

"Generally speaking, grain movements to the Minneapolis-St. Paul market are, and traditionally have been, dominated by rail, while traditionally a very large part of grain movements to the Duluth-Superior market have been made by truck; this despite the fact that grain arriving by truck has been typically penalized anywhere from 1 to 10 cents per bushel..... truck participation in even the Duluth-Superior market has deteriorated significantly with the exception of barley shipments. In addition, the truck versus rail competitive situations can also be put in terms of domestic versus foreign demand: the rails have almost a total monopoly on durum and barley shipments to domestic millers and malsters in Minneapolis-St. Paul. Primary reasons are that many of the Minneapolis-St. Paul malsters simply do not have truck dump facilities and Minneapolis-St. Paul millers demand the cost savings of the transit privilege provided by railroads -- a service not available when durum is received by trucks. On the other hand, when the market is dominated by export demands and the transit privilege is not demanded, trucks have been exceedingly competitive, as in the case of the Duluth-Superior market." (9)

It should be noted that it is the export market that is anticipated to be the primary source of increased demand for barge traffic.

Extensive information on the modal split of grain transportation does not appear to be available for South Dakota movements to Minnesota. The lack of information on modal split of grain transportation in Minnesota has already been discussed.

COAL

Coal has, in terms of tonnage, been the leading commodity received by ports in the St. Paul District (see Figure 3). Large amounts of coal have traditionally moved up the Mississippi from mines in Southern Illinois, and along the Ohio River. This has been a source of supply for utilities (the major user) and other coal users along the river. Coal receipts in the upper portion of the St. Paul District for the years 1970-1973 are summarized in Table 8.

Table 8

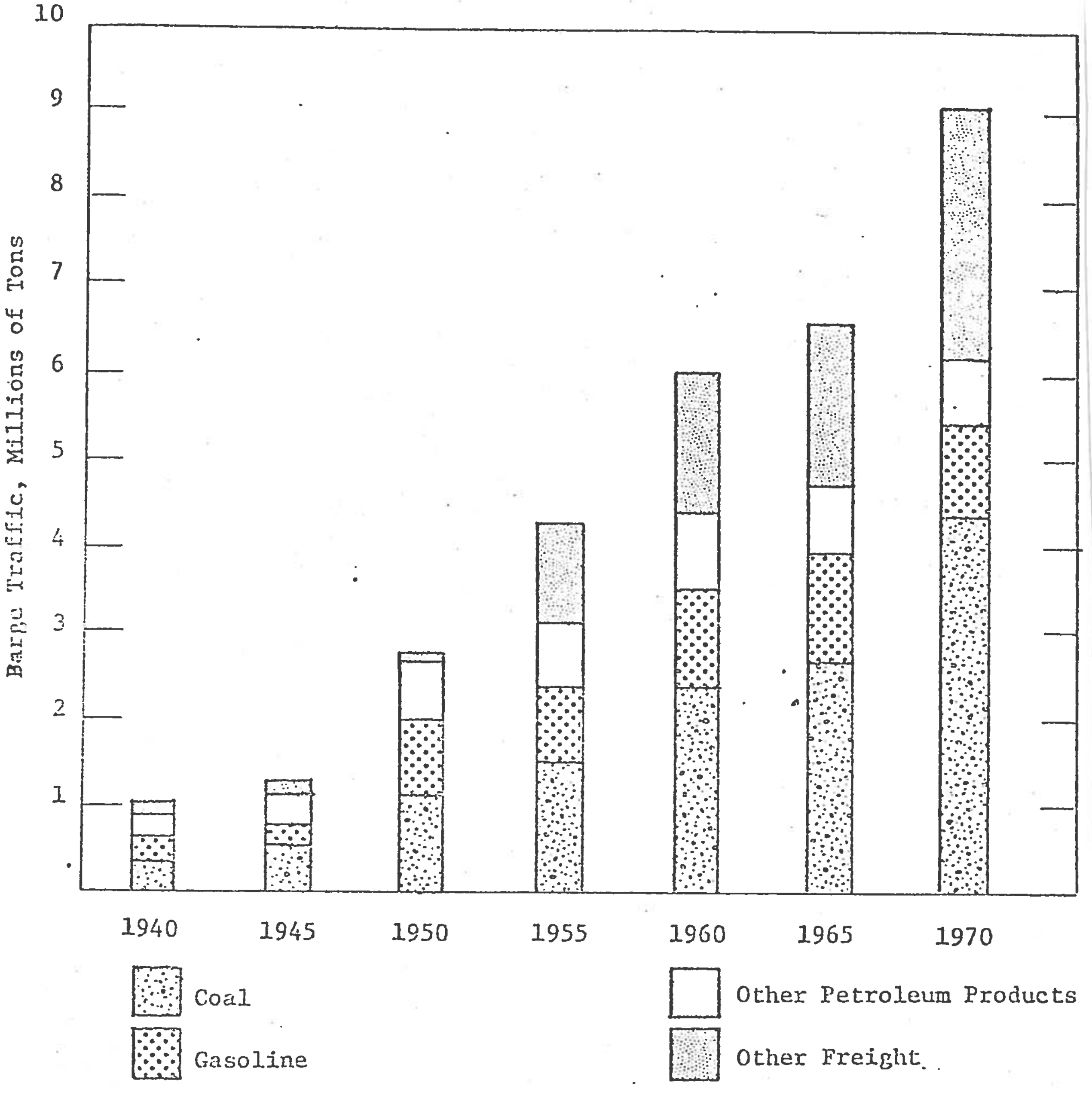
RECEIPTS AND SHIPMENTS OF COAL BY BARGE FOR PORTS ABOVE LOCK AND DAM 2 AND ON THE BLACK AND ST. CROIX RIVERS 1970-1973. (IN TONS)

Commodity/Year	1970	1971	1972	1973
Coal & Lignite (receipts)	2,572,863	2,450,426	3,066,293	2,222,901
Coal & Lignite (shipments)	10,872	44,925	320,577	643,490

Source: U.S. Army Corps of Engineers, Waterborne Commerce of the United States. (1970-1973).

Figure 3

RECEIPTS OF MAJOR COMMODITIES - ALL PORTS
ST. PAUL DISTRICT



Source: U.S. Army Corps of Engineers, Final Environmental Impact Statement, Operation and Maintenance of 9-foot Navigation Channel Upper Mississippi River Head of Navigation to Guttenberg, Iowa, Vol. II, p. 125.

In recent years, however, coal has begun leaving St. Paul District ports. The volume has grown from 10.9 thousand tons to 643.5 thousand tons in only three years (see Table 8). This coal is transshipped to barges after it has moved by rail from mines in Montana and Wyoming. Barge movements of Western coal cover a relatively short distance. This coal generally moves from ports in Minneapolis to power plants on the St. Croix and Minnesota Rivers.

It should be noted that the listing in Waterborne Commerce of the U.S. for internal receipts includes shipments that moved out of ports within the district. It seems, therefore, that increasing portions of the coal received by St. Paul District ports in recent years have been transshipped Western coal that has moved only a short distance on the river system.

Data on the amount of coal moving into the Twin Cities area by rail and truck is not available in published form. We would not expect that there has been any long haul movement of coal by truck. Some transshipment by truck from rail and barge is likely, however.

Indications are that there have been significant increases in the amount of coal moving into the area by rail. New coal-burning power plants have been built which receive coal by rail from the West. No precise volume figures are available on the amount of coal that has moved in by rail, however. It is possible that such data could be obtained by soliciting information from individual utilities and industries that burn coal. Additional data might also be obtained from railroad companies.

PETROLEUM PRODUCTS

There is a significant movement of petroleum products on the river system in the St. Paul District. The great majority of the movement is inbound. Figure 3 gives an indication of historical receipts of petroleum products by St. Paul District ports. Gasoline is the principal petroleum product received in the District. Table 9 shows the receipts and shipments of petroleum products in the District for the years 1970-1973. It should be remembered that products shipped from one District port may well be included in the receipts of another port in the District.

TABLE 9

RECEIPTS AND SHIPMENTS OF PETROLEUM PRODUCTS BY BARGE FOR PORTS ABOVE LOCK AND DAM 2 AND ON THE BLACK RIVER, 1970-1973. (IN TONS)

Commodity/Year	1970	1971	1972	1973
Receipts				
Gasoline	1,032,485	1,124,950	1,158,941	1,028,790
Jet Fuel	62,706	67,150	107,228	78,225
Kerosene	44,524	98,012	38,582	9,922
Distillate Fuel Oil	468,478	303,617	341,882	360,985
Residual Fuel Oil	9,704	18,224	38,706	33,825
Lubricating Oils and Greases	17,124	16,260	18,188	14,620
Naptha, Petro and Solvents	21,996	22,998	8,188	8,001
Asphalt tar and Pitches	8,211		6,991	39,997
Total	1,665,228	1,651,211	1,718,706	1,574,365
Shipments				
Total	76,926	227,736	166,084	70,926

Source: U.S. Army Corps of Engineers, Waterborne Commerce of the United States. (1970-1973).

Waterborne Commerce of the United States does not indicate the pattern of movement of petroleum products. Appendix J of the *Upper Mississippi River Comprehensive Basin Study* addresses this question: "Varied petroleum and petroleum products move through the system each year. The principal movement is northbound from the Gulf-New Orleans-Vicksburg reach and from St. Louis to Havana-Peoria, to Chicago on the Illinois Waterway, and to Minneapolis-St. Paul on the Mississippi River. Southbound movements originate at the Twin Cities area, Chicago, and St. Louis with their destinations lying principally along the Ohio River System." (8, p. J-38)

Specific information on volume movements of petroleum products by other modes does not appear to be available. "Petroleum products are carried by pipeline, barge, railroad tank cars, and trucks. All of these means are used in Minnesota, but reliable summary data do not seem to be available as to the extent and regional distribution of each." (14, p. 34)

Apparently no crude oil enters Minnesota by barge. Virtually all crude oil enters the state by pipeline, with most coming from Canada. Table 10 shows the receipts of crude oil into Minnesota and Wisconsin for the years 1960-1973. Crude oil pipelines in Minnesota feed the state's three refineries at Wrenshall, St. Paul Park, and Pine Bend. There is also a substantial volume of crude oil that passes through the state on pipelines.

Table 10
Minnesota - Wisconsin

CRUDE OIL: REFINERY RECEIPTS

(By Mode Of Transportation)

Thousand Barrels (1960 - 1979)

Year	Total	Interstate			Foreign Crude	
		Pipeline	Tank Cars And Trucks	Tankers And Barges	Pipeline	Tankers And Barges
1973	70,691	6,093	-	-	64,598	-
1972	64,462	6,456	-	-	58,006	-
1971	60,463	5,673	-	-	54,790	-
1970	55,001	5,339	-	-	49,662	-
1969	56,032	6,556	-	-	49,476	-
1968	49,086	6,683	-	-	42,403	-
1967	42,162	7,772	-	-	34,390	-
1966	41,814	10,106	-	-	31,708	-
1965	39,436	10,118	-	-	29,318	-
1964	36,933	9,555	22	1,225	26,131	-
1963	33,377	8,630	502	2,552	21,693	-
1962	30,448	6,761	2,031	1,361	20,295	-
1961	29,534	4,849	3,631	2,186	18,868	-
1960	27,959	1,149	5,279	1,964	19,567	-

Source: Steven D. Emmings, Minnesota: Historical Data on Fuels and Electricity. Minnesota Energy Project, pp. 40.

CHEMICALS AND ALLIED PRODUCTS

Table 11 gives a summary of barge movement of chemicals and allied products for the years 1970-1973 taken from Waterborne Commerce of the United States. While the tonnage has fallen off in recent years, the trend has been one of increasing volume.

Table 11

Receipts and Shipments of Chemicals and Allied Products by Barge for Ports Above Lock and Dam 2 and on the Black and St. Croix Rivers, 1970-1973 (in tons)

Receipts	1970	1971	1972	1973
Fertilizers	189,665	277,108	171,225	164,616
Other Chemicals	72,933	119,002	112,269	56,031
Total	262,598	369,110	283,494	220,647
Shipments				
Fertilizers	20,909	16,124	24,832	1,333
Other Chemicals	3,520	1,375	1,401	
Total	24,429	17,499	26,233	1,333

Source: U.S. Army Corps of Engineers, Waterborne Commerce of the United States, (1970-1973).

The movement of fertilizer is of special interest because of its relationship to agriculture and to grain movements. Table 12 gives a summary of the movement of fertilizer (by type) for the years 1970-1973 taken from Waterborne Commerce of the United States. This data excludes any receipts in the St. Paul District below Locks and Dam 2. Significant receipts of fertilizers might be expected in that stretch. "The central location near the Gulf Coast of major sources of raw material for the manufacture of both nitrogen and phosphate base agricultural chemicals makes these products ideally suited for river transportation. Major destinations for agricultural chemicals are St. Louis, Peoria, Chicago, and Minneapolis-St. Paul." (8, p. J-39)

Table 12

Receipts and Shipments of Agricultural Chemicals from Ports Above Lock and Dam 2 and on the Black River, 1970-1973 (in tons)

Commodity/Year	1970	1971	1972	1973
Receipts				
Nitrogenous Chemical Fertilizers	17,743	21,840	19,880	21,182
Phosphatic Chemical Fertilizers	61,469	65,849	33,958	16,729
Fertilizer & Materials Nec.	110,453	189,419	117,387	126,705
Total Receipts	189,665	227,108	171,225	164,616
Shipments				
Fertilizer & Materials Nec.		2,674	6,925	1,333
Potasic Chemical Fertilizers	19,460	13,450	17,907	
Total Shipments	19,460	16,124	24,832	1,333

Source: U.S. Army Corps of Engineers, Waterborne Commerce of the United States, (1970-1973).

As with other commodities, information on rail shipments of farm chemicals is lacking. A 1973 study of 14 agricultural cooperatives on or near the river system suggests that there have been substantial rail shipments of fertilizer out of the South and Southeast into the Midwest (6). The report suggests that there is direct competition between barge and rail for fertilizer movement. The study, however, does not specify movement in the St. Paul District and only involves a portion of the entire fertilizer movement.

Further study is needed to determine fertilizer movement by mode in the St. Paul District.

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CHAPTER X

BULK COMMODITY PROJECTIONS

The projections of bulk commodities can be grouped into three categories; (1) Iowa State University projections, (2) Corps of Engineers projections and (3) others. The Iowa State projections are based on either a large linear programming model or a requirements approach. They only project agricultural commodities to 1980, 1985 and 2000. In contrast, the studies done for the Corps or by the Corps are for 50 years and include a wide range of bulk commodities. These studies range from the recent Kearney report to the Comprehensive River Basin Study done during the 1960's. The final category of projections includes adhoc studies that have projected agricultural commodity production and exports.

A. Iowa State Projections

The most important of these projections in terms of transportation is the Fedeler, Heady and Koo study. (3) It divides the U.S. into 152 producing and 78 consuming regions and projects agricultural commodity flows within and between regions. They consider ten models of transportation costs and their impacts on the three major modes of transportation. The projections are to 1980 and include feed grains, soybeans, wheat and cotton. The latter being of no importance in the northern reaches of the Upper Mississippi.

A basic set of transportation costs and grain demands and production are projected for a "normal" 1980 year. This information is incorporated into the base model. Normality means the projection of past average trends.

All costs and prices are based on 1972 value of the dollar. Transportation data represent costs and not rates. The model represents a year's activity, but the demands for and transportation of feed grains and soybeans are divided into two periods. This is because of the restriction on water traffic during December through March.

The export projections for the base model seem fairly conservative, particularly for feed grains and wheat (see Table 1). "Projections of soybean exports for 1980 are substantially greater than exports in 1973; such is not the case for feed grains and wheat. Although the demand for soybeans increased in 1972 and 1973, the increased demand ..... resulted in higher prices rather than increased exports. In fact, the percentage increase in soybean exports in both 1972 and 1973 was below the average annual increase from 1966 to 1973. In contrast to feed grains and wheat, there were no large stocks of soybeans stored from production in previous years that could be exported in 1972 and 1973."(3, p. 74) The percentage increase in soybean exports for the seven years from 1966 to 1973 was 98 percent, while the increase for the high export model, X, for 1973 to 1980 was only 88 percent.

Projections of increases in production between 1973 and 1980 also follow past trends. Feed grain production is projected to be 13.7 percent greater in the base model and 17.2 percent greater with a 25 percent increase in exports in Model X. Soybeans production in 1980 is projected to increase 14.8 percent under the base model and 32.1 percent under Model X. In

Table 1

U.S. Grain Production and Exports,
1972, 1973 and 1980

	Feed grains	Wheat (1,000 tons)	Soybeans
Production:			
1972	196,692	46,348	38,119
1973	201,654	51,342	46,996
Base Model 1980	229,350	46,321	53,960
Model X 1980	236,276	52,121	62,075
Exports:			
1972	30,598	25,207	18,295
1973	45,541	42,691	20,768
Base Model 1980	27,500	22,380	31,240
Model X 1980	34,375	27,975	39,050

Source: Fedeler, Heady and Koo (3)

contrast, wheat production is projected to be 9.8 percent less than in 1973 under the base model and only 1.5 percent higher under Model X.

Grain production was projected for Minnesota (see Table 2). The two projections (base model and Model X) differed not only in the total amount of grain produced, but also in the mix. Soybeans increased by almost a third under a 25 percent increase in exports, while corn declined.

The quantity of grain going down the Mississippi from Minnesota was estimated for five different cost models (see Table 3). Soybeans went down the river in all models, while no wheat was shipped under any model. Corn was shipped down, except under the model where barge rates increase 20 percent and under the one where 25 percent of the Gulf export demand was shipped to Seattle. Under these two models, rail picked up much of the grain exports. "The reassignment of exports from the Gulf to Seattle results in a substantial increase in share of traffic carried by rail..... The Corn Belt does not lose its comparative advantage in production but ships more of its production to satisfy domestic demands." (3, p. 7)

Other conclusions are that "rail is not competitive with water for moving grain from the Corn Belt to the Gulf if the grain is produced near the water of the Mississippi River System." (3, p. 8) "Trucks are used only for movements shorter than 100-125 miles under the cost minimization systems represented by the models." (3, p. 9) "The results of the models show that rail should haul a substantial fraction of the grain to rivers for barging." (3, p. 190)

Table 2

Minnesota Grain Production,
1969 and 1980

	Feed grains	Wheat	Soybeans
		(1,000 tons)	
1969	12,296	726	1,922
Base Model 1980	18,262	935	3,072
Model X 1980	18,077	1,183	3,929

Source: Fedeler, Heady and Koo (3)

Table 3

Minnesota Grain Shipments by Water, 1980

	Feed grains	Wheat	Soybeans
		(1,000 tons)	
Base Model	1,543	0	1,102
Model IV	1,835	0	1,485
Model VI	0	0	211
Model IX	0	0	185
Model X	1,201	0	1,485

Cost assumptions under each model:

Base model assumes single car rail costs.
Model IV assumes a 20 percent increase in rail costs over the base model.
Model VI assumes a 20 percent increase in barge costs.
Model IX assumes 25% of Gulf export demand is shipped to Seattle.
Model X assumes a 25% increase in exports.

Source: Fedeler, Heady and Koo (3)

Baumel and others projected commercial grain sales and fertilizer applications to 1979-1980 and 1984-1985 for Iowa counties. (2) Production is projected in a four-step process. "Step one was to project corn, oats, and soybeans production to 1979 and 1984 and livestock numbers to 1980 and 1985 for the state. Secondly, county percentage shares of state production were projected through a non-linear regression of past shares. County production was then derived by multiplying the projected state production total by the county percentage share of total production. Projections of county livestock numbers were then used in the third step to estimate 1980 and 1985 grain feeding requirements. The final step was to subtract grain feeding requirements and soybean seed requirements from projected levels in order to obtain estimates of grain to be moved through commercial channels." (2, p. 7)[1/]

Iowa's grain and livestock production projections were based on Iowa's share of recent USDA projections of national production (see Tables 4 and 5). Iowa's share was calculated from past trends from 1959 through 1972. The projected slowly increasing share of corn is on trend, while the projected increase in share for soybeans is below trend. The projected declining trend for oats is above the 1959-1972 trend.

The USDA projections were based on a national demand analysis assuming a U.S. population of 233.7 million people and an average real growth rate of 4.0 percent by 1985. Two alternative grain export levels

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1/ A similar study is underway to project grain production and sales in Minnesota at the Department of Agricultural and Applied Economics, University of Minnesota.

Table 4. U.S. Feed Grain Production in Millions of Bushels

Commodity	Low Exports 1979	Low Exports 1984	High Exports 1979	High Exports 1984
Corn	6,602	7,141	7,122	7,589
Soybeans	1,765	2,052	1,880	2,241
Oats	803	816	803	816

Source: Baumel and others. Card Report 51. (2)

Table 5. Iowa's Share of National Feed Grain Production

Commodity	1979	1984
	percentage	
Corn	21.22	21.30
Soybeans	17.36	17.76
Oats	9.73	9.39

Source: Baumel and others. Card Report 51. (2)

Table 6. Projected Net U.S. Feed Grain Exports in Millions of Bushels

Commodity	Low Exports 1980	Low Exports 1985	High Exports 1980	High Exports 1985
Corn	1150	1200	1575	1658
Soybeans	750	950	925	1158

Source: Baumel and others. Card Report 51. (2)

were considered: (1) low commodity exports based on past export levels excluding 1972-1973 and 1973-1974 and (2) high export levels based on a continuation of recent high export levels (Table 6). Domestic consumption was assumed to stay constant under both alternatives.

"Fertilizer consumption was projected to the 1979 and 1984 fertilizer seasons by multiplying projected crop acres by the projected fertilizer application rates per acre. Projected application rates were based on 1970-1971 levels adjusted upward to reflect increased productivity growth in corn and soybean yields." (2, p. 21) The projected rates of increase in fertilizer applications were 6.9 and 11.5 percent for the average productivity growth rate and 11.5 and 15.0 percent for the high productivity growth rate.

Both the increase in crop acreage and the fertilizer applications cause total Iowa fertilizer requirements to increase substantially (Table 7). The projected increases range from 65 to 78 percent for P_2O_5 (phosphorous), 82 to 96 percent for K_2O (potash) and 39 to 48 percent for nitrogen (N). The larger increases for P_2O_5 and K_2O are due to their use for soybeans.

Table 7. Projected Fertilizer Applications in Tons of Primary Nutrients, N, P_2O_5 and K_2O, Iowa

Year	N	P_2O_5	K_2O
1959	93,739	117,532	66,595
1971	701,768	442,566	352,940
1972	662,568	402,108	367,055
1973	643,696	380,301	391,041
Low Export Ave. Prod.			
1979	903,758	622,563	574,236
1984	978,104	697,846	643,642
Low Export High Prod.			
1979	903,002	621,991	573,820
1984	977,551	697,349	643,699
High Export High Prod.			
1979	973,151	667,964	616,052
1984	1,039,169	750,508	691,765

Source: Baumel and others. Cord Report 51. (2)

The last Iowa State projection of grain to be considered is the one made for the National Water Commission. (4) These projections were done earlier than the other two and are based on different assumptions. Population projections used were Census series B through D, which are now considered high. On the other hand, the 1967-69 average export levels used are probably too low in light of the dollar devaluation and production in the rest of the world (see Table 8).

Martin Abel points out that the assumption of constant exports is unrealistic, even if one looks at 1955 through 1971 exports. "From 1955 through 1971 the value of U.S. agricultural exports increased from $3.1 billion to $7.8 billion, and at a fairly uniform rate." (1, p. 4) The level in 1972 was $8.0 billion and in 1973 $12.9 billion. Abel also points out that an extrapolation of the 1955-71 trend to 2000 would give a level of agricultural exports of $14.1 billion. This is 2.2 times the 1967-69 average of only $6.3 billion.

Iowa State makes seven projections to 2000 for crops in the Upper Mississippi River Basin (see Table 9).[2/] The projections include different assumptions concerning farm policy, population, water prices, exports and technology. However, the assumptions do not greatly affect the end results. For example, the low projections for corn and soybean grain production is 2 billion bushels, as compared to 2.3 billion bushels for the high projection. The difference is only 15 percent.

2/ Upper Mississippi River Basin includes parts of six states; Illinois, Iowa, Indiana, Missouri, Wisconsin and Minnesota, which drain into the Mississippi River from Cairo, Illinois to the headwaters.

Table 8

Exports of U.S. Grains and Oilseeds 2000
in Thousands of Bushels*

Commodity	Quantity
Corn-Soybeans	710,264
Oats-Barley	51,292
Wheat	637,115
Oilseeds	218,992

* Average 1967-69 commercial and government exports

Source: Iowa State University, Agricultural Water Demand, Nov. 1971 (4)

Table 9

Crop Production in the Upper Mississippi Basin for 2000

Models*	Wheat (000 bu.)	Corn and Sorghum Grain (000 bu.)	Oats (000 bu.)	Corn and Soybean Silage (000 tons)	Soybean Oilseed (000 cwt.)
A	225,049	2,292,743	188,391	79,020	234,825
A_1	225,049	2,221,639	179,206	78,205	246,272
A_2	225,049	2,135,929	164,593	76,878	251,891
A_3	225,049	2,140,897	165,440	76,955	251,891
B	225,049	2,177,409	162,841	76,144	224,353
C	110,981	1,981,043	259,968	62,576	296,507
D	225,049	2,294,259	250,368	61,417	309,215

Source: Iowa State University, Agricultural Water Demand, Nov. 1971. (4)

* Assumptions for each model

Models	Farm Policy	Population	Water Price	Exports	Technology
A	free mkt.	Level C	Present	67-69 ave.	trend
A_1	" "	" "	15$	" "	"
A_2	" "	" "	22.50$	" "	"
A_3	" "	" "	30$	" "	"
B	" "	Level D	Present	" "	"
C	annual land retirement	" "	"	" "	"
D	free mkt.	Level B	"	double 67-69 ave.	advanced

B. Corps of Engineers

The two major studies reviewed in this section include the Comprehensive River Basin Study published in 1970 and the Kearney report, which is just in draft form. (5, 7, 12) Several others were reviewed, but due to the failure of the reports to specify assumptions the projections were of little use. (8, 9, 10) Two additional reports appeared to be closely related to or are earlier parts of the Kearney study. (6, 11)

Both studies consider a wider range of commodities than did the Iowa State work. The Upper Mississippi and Kearney reports considered coal, grain, petroleum, iron and steel, sand and gravel, cement and stone, and chemicals. (7) The Upper Mississippi projections to 1980, 2000 and 2020 include, in part, the states of Illinois, Indiana, Iowa, Minnesota, Missouri and Wisconsin. The Waterborne projections include the section of the Upper Mississippi River from Cairo, Illinois to Minneapolis, Minnesota. The Kearney projections, including the adjusted MarAd (Maritime Administration) projections, are based on commerce through Locks 26.[3/]

3/ Exhibit D-3 in the Kearney report [Draft Formulation Evaluation Report DM No. 11 Locks and Dam No. 26 (Replacement) appendices] summarizes the adjusted MarAd projections of Locks 26 traffic volumes. The adjusted projection is based on the annual growth rates inherent in the original MarAd projections applied to the actual base year (1969) tonnages moving through the locks. This actual tonnage totaled 42.18 million tons, in contrast to the MarAd base year tonnage estimated at 30.8 million tons -- an underestimation by about 27 percent.

Exhibit D-1 in the Kearney report contains the unadjusted MarAd data, showing movements by commodities from various subgroups of BEA regions north of Locks 26 to various subgroups of BEA regions south of the Locks 26. Each exhibit shows 1969 total, rail, truck and water movements, together with projections (total) from 1975 through 2000, as well as water projections for Year 2000. These projections can be useful for individual commodities for various reaches of the river, e.g., for total and water projections involving the Upper Mississippi River.

Grain

The Comprehensive River Basin projections of grain traffic were based on; (1) grain production in the basin prepared by Economic Research Service, (2) total U.S. grain exports, (3) Gulf Coast grain exports and (4) waterborne grain traffic from basin areas to Gulf ports. (7, 12) "A detailed breakdown of origin and destination of grain shipments from the Upper Mississippi River and tributary ports for the period from 1959-64 revealed that approximately 25 percent of total U.S. grain exports, or 40 percent of total Gulf Coast grain exports, were transported via the Upper Mississippi River to Gulf Coast ports for export." (7, p. J-55) It was assumed that the Upper Mississippi would continue to transport approximately 40 percent of the Gulf Coast grain exports and/or 25 percent of U.S. grain exports. The total traffic to the Gulf in 1964 was 13.7 million tons.

The grain production for the Upper Mississippi Basin was estimated by allocating a share of the projected total demand for U.S. grains to the basin (Table 10). The share going to the Upper Mississippi increases slightly over time.

The Upper Mississippi River to Gulf Coast grain traffic was projected, based on the above assumptions, to increase to 21.0, 34.0 and 50.0 million tons for 1980, 2000, and 2020, respectively. "This represents the medium assumption with low and high alternatives representing a decreasing or increasing Upper Mississippi River supply of Gulf Coast grain exports." (7, p. J-55)

The future movement of grain, says the Kearney report (5), is tied to the production capacity of the Upper Mississippi region and the future policy

Table 10

Demand for Food and Feed Crops 1959-2020
(thousands)

	1959-61	1980	2000	2020
U.S.				
Feed Crops (tons)	149,287	220,380	297,970	404,550
Food Crops (bu.)	1,826,968	3,206,833	4,424,649	6,128,516
UMRB				
Feed Crops (tons)	49,611	76,648	103,580	140,610
Food Crops (bu.)	274,109	541,155	746,760	1,034,419

Source: U.S. Department of Agriculture (12), p. N-60.

decisions for export trade. Kearney expects grain movements through the Locks 26 to grow at an average annual rate of 1.2% from a base of 23.52 million tons in 1973 to 30.20, 42.90 and 47.50 in 1980, 2000 and 2020. Adjusted MarAd projections run somewhat lower than the other projections, moving from 20.32 million tons in 1980 to 43.99 in 2020.

Bituminous Coal

The coal traffic is based on need for electric power generation. Federal Power Commission shows an 18-fold increase in 2020 over the 1960 level of electric power required. Nineteen percent of the projected thermal supply by 2020 will come from fossil fuel sources. Based on these requirements, projection of coal production in the Basin shows a twofold increase from 1960 to 2000, with a slight decline in 2000 to 2020. According to the River Basin projections, waterborne coal movement will go from 6.3 million tons in 1964 to 9.0 and 10.0 million tons in 1980 and 2000, with a decline to 9.0 million by 2020. High and low projections were made based, for the most part, on alternative assumptions on the comparative levels of nuclear power.

The Kearney report ties the future movement of coal to the future of the energy shortage and the decisions in regard to Project Independence. The report states that the use of coal by utilities will be the primary determining factor. Kearney expects coal movements to grow at an average annual rate of 2.5% to a peak of 16.24 million tons in 2020 and level off at that amount. The adjusted MarAd projections begin with a movement of 10.64 million tons in 1980, and by 2020 the expected movement is 24.57

million tons. Kearney considers these projections abnormally high.

Petroleum and Petroleum Products

The River Basin Study projected the transportation of petroleum and petroleum products to decline from 11.6 million tons in 1960-64 to 9.6 million tons in 1980. The major reasoning being the construction of pipelines in the lower reaches of the Upper Mississippi. Normal growth in "heavy" petroleum products was assumed for the period. After the initial decline, waterborne movements were projected to increase to 15.0 and 20.0 million tons by 2000 and 2020. High and low projections reflect different assumptions on the effect of pipeline activity. A continuance of the waterborne movement of petroleum in the upper reaches of the Upper Mississippi, from Minneapolis to the mouth of the Illinois River, is expected. Traffic to and from the Minneapolis-Rock Island areas, which in the middle 1960's accounted for 25 to 30 percent of the total traffic, was also projected to continue.

The Kearney report projections for petroleum products follow the River Basin Study projections very closely, moving from 9.00 to 13.30 to 19.30 million tons for 1980, 2000, and 2020. The adjusted MarAd projections, on the other hand, are very low relative to the other two projections, beginning with 8.19 million tons in 1980 and increasing to only 8.91 million tons in 2020. According to Kearney, MarAd projections assumed a decline in waterway's model share due to pipeline competition. In its most recent report, Kearney believes pipeline construction is being deterred by a number of factors.

Chemicals

The River Basin Study states that "The growth in waterborne commerce of industrial chemicals is expected to correspond with projected growth in the production of iron and steel." (7, p. J-58) Thus, waterborne movements of industrial chemicals and sulphur is projected to increase from 2.2 million tons in 1960-64 to 4.9, 10.3 and 18.2 million tons in the three projected years. The high and low projections are based on different assumptions concerning the growth in iron and steel products.

In regard to agricultural chemicals, the River Basin Study says, "Waterborne tonnage of agricultural chemicals is projected to show the strongest average annual growth of all commodity groups on the Upper Mississippi River." (7, p. J-58) The rate of increase during 1957-62 was 14 percent compounded annually and was second only to selected grains on the river. Waterborne movement of agricultural chemicals on the Upper Mississippi River is projected to increase to 6.7, 9.6 and 20.0 million tons in 1980, 2000 and 2020, as compared to 1.2 million tons in 1960-64. This represents over a 10 percent compound growth rate in the early period and a slower rate in the remaining two periods. The high and low projections are based on alternative assumptions concerning the level of demand and reapplication results.

The River Basin Study projections on industrial and agricultural chemicals combined total 11.6, 23.3 and 38.2 million tons for 1980, 2000 and 2020.

The comparative figures from the Kearney report are 8.10, 20.80 and 39.40 million tons for the same future years. These projections assume that (1) industrial chemical movements will grow at a rate close to the growth projections by OBERS series E for the industry, (2) agricultural chemicals will grow at a somewhat slower rate, (3) no shifts in supply nor demand areas and (4) no model shifts. The adjusted MarAd projections first run lower than the other two and then are higher, increasing from 7.93 million tons in 1980 to 26.22 in 2020.

C. Other Projections

The State Planning Agency makes grain production projections for Minnesota to 1980. (13) Because of crop yield variations, the report shows projection ranges for each major cash crop. The report then aggregates each of these projections to obtain a composite projection range varying from about 425 million bushels (reflecting 1974 and other low production years) to 775 million bushels (an extension of 1973 crop year productivity).

The report also shows the percentage of grain shipped by rail from each Minnesota Development region. Tons of total commodities and grain shipped from Duluth-Superior ports are shown for 1968 to 1973 and for the same period by barge from Minneapolis-St. Paul.

The last article to be reviewed is Willard Cochrane's general look at agriculture for the next ten years (1974-1984). He makes no numerical projections, but his ideas about fluctuations in agricultural supply and demand are key for the projections section.

Cochrane points out two aspects of U.S. agriculture which loom large in any future projections: (1) U.S. grain producers are an integral part of the world market due to commercial trade and food aid, and (2) "the aggregate world demand for grain is highly inelastic. Thus, any small changes in the world supply of grain send relatively large price shocks throughout the world trading system, including the United States." (14, p. 989) He also points to weather fluctuations and changes in national trade policies as two other important factors which make it difficult to estimate world food supplies.

He concludes by predicting that real cost of producing food will rise. More important for transportation, he predicts that "the export for American farm products (based in part on the food needs of the LDC's* but more importantly on the upgrading of diets in the developed nations) will remain strong." (14, pp. 991-2) In addition, he predicts that unless the U.S. or the world develops reserve stocks, the future will see wider food price fluctuations. This also implies wider fluctuations in agricultural exports caused by variations in weather (particularly in importing countries) and national trade policies of various countries. All of this indicates a future with greater fluctuation in grain transportation needs for the U.S. and the Upper Midwest than have been experienced in the past.

D. Summary

The Iowa State projections (3) suggest modest increases in exports of

* Less Developed Countries

feed grains, soybeans and wheat. They suggest substantial increases in fertilizer applications, which implies substantial increases in fertilizer movement.

Table 11 is a summary comparison of the River Basin Study, Kearney, Inc. report and the Adjusted MarAd projections. In making comparisons, the reader must keep in mind that the projections may differ because of differences in underlying assumptions. The projections may also differ because of differences in classifying commodities. Finally, the River Basin projections may differ from the other two because the former are based on Upper Mississippi commerce, whereas the latter two are based on all commerce going through Locks 26.

In some instances, the projections from the separate studies are very close in the near term but deviate considerably in the longer term, and in some instances the opposite occurs. In other instances, the projections are very close over all future years.

For grain, projections for 1980 range between 20 and 30 million tons and for 2020 between 44 and 50 million tons.

For coal, the 1980 projections vary between 8.5 and 10.64 million tons and for 2020 between 9.0 and 24.57 million tons.

For petroleum, the projections range from 8.19 to 9.6 million tons in 1980 and from 8.91 to 20.00 in 2020.

Because of the uncertainty with respect to future energy policy and energy developments, longer term projections can be expected to vary con-

Table 11

Comparisons of Projected Waterborne Commerce
(Mill. of tons)*

Year in Future	Comprehensive River Basin Study 1/			Kearney, Inc. Report 2/			Adjusted MarAd 2/
	Low	Medium	High	Low	Most Likely	High	
	Selected Grains 3/			Grains 4/			Grains 4/
1980	19.0	21.0	25.0	26.00	30.20	33.25	20.32
2000	28.0	34.0	45.0	32.00	42.90	45.10	29.24
2020	34.0	50.0	75.0	40.75	47.50	61.00	43.99
	Bituminous Coal & Coke			Coal			Coal
1980	8.2	9.0	10.5	7.0	8.5	8.9	10.64
2000	7.5	10.0	13.5	12.10	14.0	16.2	16.95
2020	6.5	9.0	15.0	14.00	16.25	18.20	24.57
	Petroleum & Petroleum Products 5/			Petroleum Products 6/			Petroleum Products 6/
1980	8.3	9.6	10.7	8.70	9.00	9.10	8.19
2000	11.2	15.0	19.3	11.15	13.30	20.00	8.55
2020	13.7	20.0	28.7	13.70	19.30	24.25	8.91
	Chemicals 7/			Chemicals 8/			Chemicals 8/
1980	9.7	11.6	14.3	7.60	8.10	9.00	7.93
2000	16.8	23.3	33.3	17.00	20.80	22.00	13.88
2020	24.6	38.2	59.5	37.30	39.40	48.00	26.22

* Projections for iron and steel; cement, stone, sand and gravel (mining); all others are not included as these categories are relatively minor.

1/ Commerce on Upper Mississippi River -- the section of the river from Cairo, Illinois at the mouth of the Ohio River to Minneapolis, Minnesota.
2/ Commerce going through Locks 26.
3/ Principally corn, wheat, soybeans, but includes rye, barley, oats, inedible vegetable oil
4/ Corn, soybeans, wheat.
5/ Gasoline, gas oil, dist. fuel oil, crude petroleum, jet fuel, kerosens, resid. fuel oil, petroleum asphalt, lub. oils and grease, naphtha, other.
6/ Residual fuel oil, gasoline, distillate fuel oil, other.
7/ Industrial: Coal tar, benzol, sulphuric acid, alcohols, sodium hydroxide, pigments, pai varnishes. Agriculture: Nitrogeneous fertilizer, phosphate rock, superphosphate, potash fertilizer materials.
8/ Industrial: Alcohols, sodium hydroxide, crude coal tar, gas products. Agriculture: Nit geneous fertilizer and superphosphates.

siderably. The longer term projections for both coal and petroleum show considerable variation relative to the near-term projections.

For chemicals, 1980 projections vary from 7.93 to 11.6 million tons, while 2020 projections range from 26.22 to 39.40 million tons. All three projections here suggest large growth.

E. Conclusion

Five important questions remain unanswered or only partly answered after the review of literature concerning future movements of bulk commodities. First, will the exports of grain continue to grow? Second, will Minnesota's grain production continue to expand and meet export demands? Third, what will be the impact on transportation of the shift in energy demands to western coal? Fourth, will there be a slow down in the growth in demand for agricultural chemicals due to environmental concerns or higher prices? Finally, are there some basic shifts occurring in the share of commodities shipped by different modes?

The outlook for continued growth in grain exports seems to be good. However, with this growth there seems to be a high probability of greater year to year fluctuations. This could have a substantial impact on transportation needs, with approximately 20 percent of the U.S. corn, 50 percent of the U.S. soybeans and 2/3 of the U.S. wheat exported. Both corn and soybean exports are currently an important market for Minnesota's grain production. Thus, what happens to foreign markets will directly affect the production and transportation needs of the region.

Probably the biggest uncertainty in transportation needs is for energy supplies. Traditionally, coal has come up the Mississippi from Illinois and oil has come from Canada by pipeline. The future appears to call for much more coal from the west and more movement of oil from the south. However, the modes and routes by which these new sources of energy will move is still uncertain.

One of the fastest growing commodities transported on the Upper Mississippi has been agricultural chemicals. Yet there are some reasons to expect this growth to decline. Prices of fertilizers have risen rapidly over the past few years and caused a reduction in fertilizer use. However, these reductions have been modified by fertilizer price declines in the spring of 1975. Environmental quality considerations may also limit increases in the applications of fertilzers and insecticides.

Finally, many of the projections of future waterborne shipments on the Upper Mississippi have assumed constant shares among modes. Energy shortages and/or new transportation methods (unit trains) could change the past trends in bulk commodity movements.

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CHAPTER XI

SUMMARY AND CONCLUSIONS

In comparing transportation costs, it should be noted that costs within a mode vary with such factors as commodity, distance and type of equipment. Some modes are ideally suited for a commodity -- petroleum and pipelines. Others are obvious misfits -- fashion goods and barges. The costs, both in the body of this report and in the following summary, are the costs of moving the commodities which typically would be shipped on that mode. In a few instances, costs have been provided for goods not typically shipped on a given mode in order to provide a benchmark figure for comparison purposes.

Barge Costs

Barge costs vary significantly between river reaches, by type of equipment and by commodity. Any study of barge transportation should recognize and allow for these variations.

Estimates of operating costs by type of equipment are available annually from the Corps of Engineers. The Donley study (in press) should provide estimates of cost differentials between river reaches and by commodities.

One study estimated the 1970 costs for barging grain from Minneapolis to New Orleans and fertilizer back to be 2.17 mills per ton-mile when operating at capacity. Operating without backhauls was estimated to increase costs per ton-mile about 10%. Level of backhauls, however, may not influence costs to this extent because of additional cleaning costs, reduced speed on return trip and possibly increased loading and unloading time. Costs per ton-mile for barge transport also vary with the time needed to complete a round trip. Costs included interest, depreciation and administration, as well as towing costs. Another study estimated 1972 barging costs for grain from Dubuque, Iowa to New Orleans without backhauls to be 2.74 mills per ton-mile. Table 1 summarizes some of the barge cost estimates.

Information on average speeds, turnaround times, cleaning cost, etc. are available from other published models but should be verified as representing current conditions prior to use in a new model.

One study estimated that the 1968 costs borne by the Federal government for operation and maintenance of the channel and improvements were .8 mill per ton-mile on the Mississippi above St. Louis and .1 mill below St. Louis.

Waterway Capacity

Waterway capacity on a given reach is much more difficult to determine than costs, because capacity is more than a function of the number of barges and towboats. Factors that influence capacity include:

a. Barges and towboats can be switched from one river reach to another on fairly short notice.

b. The ready availability of backhauls can almost double the throughput capacity of a tow.

c. The availability of terminals and similar facilities and fleeting areas, etc.

d. Operating practices of tow operators and lockmasters and the natural variations in water conditions.

Waterway capacity has been increasing regularly in terms of total net capacity of barges, towboat horsepower (but not number of towboats), and

Table 1

Cost of Water Movements

Study	Year	Commodity	Origin-Destination	One Way Distance	Cost Per Ton-Mile
Reed, Byrne, Ackley	1970	grain/fertilizer	St. Louis-New Orleans RT	1049	$ .00222
"	1970	" "	Peoria-New Orleans RT	1249	.00252
"	1970	" "	Minneapolis-New Orleans RT	1722	.00217
"	1970	" "	Kansas City-New Orleans RT	1430	.00342
Baumel et al	1972	grain	St. Louis-New Orleans one-way	1050	.00260
"	1972	"	Dubuque-New Orleans one-way	1450	.00274
Project Independence	1974	coal	Upper Mississippi or Ohio Rivers - upstream		.00532
			- downstream		.00293
Project Independence	1974	coal	Lower Mississippi - upstream		.00293
			- downstream		.00133

Sources: See Chapter II, Costs and Capacities of Water Transportation, for references.

Reed, Byrne and Ackley (4)
Baumel et al. (1)
Project Independence (10)

cargo moved to and from the Twin Cities. Existing leadtimes for delivery of new barges or towboats are up to four years. Consequently, net capacity cannot be increased substantially in the short run over what is already planned.

The Minnesota State Planning Agency concluded that the present system of waterborne transportation on the Upper Mississippi may be operating close to maximum capacity. The FEA Project Independence Report concluded that Lock and Dam 26 above St. Louis (through which all traffic from the St. Paul District going to the Gulf must pass) was already operating at capacity and delays there were frequently adding to waterway operator's costs.

One study concluded that waterway capacity generally can be increased by changing operating practices, minor physical changes to locks and approaches, and changing locking procedures.

Due to the fact that barge rates are not regulated, in times of shortage available barge capacity is allocated via higher prices. This has happened previously and, although it has the effect of rationing capacity, can be disruptive, especially if other modes are operating at or near capacity.

Rail Costs

Of rail transport alternatives for moving grain long distances, such as from Fort Dodge, Iowa to New Orleans, 115-car unit trains with hopper cars are the least costly. Of the intermodal transport alternatives for grain over a similar route, rail-barge with hopper cars is most economical. Table 2 summarizes rail costs with various types of equipment from Fort Dodge, Iowa to New Orleans.

Table 2

Costs of Rail Movements

Study	Year	Commodity	Shipment Size	Origin	Destination	Miles	Variable Cost/ Ton-Mile
Baumel et al.	1972	Corn	Single Car, Box	Ft. Dodge	New Orleans	1000	$ .01200
Fedeler et al.	1972	Corn	Single Car, Hopper	Ft. Dodge	New Orleans	1000	.00807
Baumel et al.	1972	Corn	Single Car, Hopper	Ft. Dodge	New Orleans	1000	.00934
Fedeler et al.	1972	Corn	50-Car, Hopper	Ft. Dodge	New Orleans	1000	.00747
Baumel et al.	1972	Corn	50-Car, Hopper	Ft. Dodge	New Orleans	1000	.00798
Baumel et al.	1972	Corn	115-Car, Hopper	Ft. Dodge	New Orleans	1000	.00669

Source: See Chapter III, Costs and Capacities of Rail Transportation, for references.

Baumel et al. (1)
Fedeler et al. (8)

One study estimated incremental costs of rail transport by large unit trains to be less than the incremental costs of barge transport. Another study showed unit costs (rates) for shipping grain and fertilizer by barge between the Midwest and the Gulf for a group of cooperatives to be less than by rail.

The capital costs of upgrading rail service to meet Federal Railway Administration Class I requirements are lower than the capital costs of total rehabilitation in most situations.

One study called attention to shortcomings of the ICC Cost Formula A on which many rail cost studies have been made.[1/] The shortcomings mentioned were (1) the weights used are obsolete and (2) it is a procedure for arriving at average rather than marginal costs.

Cost economies to size are important in the railway industry because of high overhead costs.

The increased average car capacity has more than offset the decreasing number of cars, so that the total freight car capacity has increased.

The range in costs of moving bulk commodities is wider for rail than for other modes. They range from the low costs for the very efficient unit trains to the high cost single box car. Consequently, estimating costs for rail is more complex than for other modes.

Truck Costs and Capacities

Most of the data and cost analysis is for grain trucks (see Table 3). Our

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1/ See pages 3 and 12 in text.

Table 3

Summary of Grain Truck Costs

Study and Year of Data	Utilization (in miles per year)	Average Loaded Trip Distance	Cost per Ton-Mile
Easter-Nevins (1974)	60,000	55	$ .047
	120,000	55	.037
	60,000	200-300	.039
	120,000	200-300	.029
Case (1974)	(a)	200-1,200	.024-.034
Fedeler (1972)	110,000	300 and 55	.026 and .030
Case (1972)	67,500	300	.040
	88,000	500	.034
	107,500	800	.030
	130,500	1,500	.027
Baumel (1971)	55,000	25	.040
	110,000	200	.025

(a) Utilization level not specified in Case's study.

Sources: (See Chapter IV on trucking costs and capacities for references)

Easter-Nevins (3)
Case (2)
Fedeler (4)
Baumel (1)

major concern in grain transportation is with the 810 bushel trucks which do almost all the commercial grain hauling. With some updating and expansion, grain truck cost data would be sufficient for intermodal analysis. However, cost data for trucking other bulk commodities is almost non-existent and inadequate.

Higher utilization levels and/or backhauls can make grain trucking very competitive with rail. In Minnesota Development Region 6E trucks appear to have the competitive edge over rail for hauls of 80 miles or less. Beyond 80 miles, trucks are competitive only at high utilization levels.

In the Upper Mississippi River Basin trucks provide a vital link between farmers, grain elevators and barges. In fact, several of the studies reviewed included trucks only for short hauls, 100 to 125 miles, usually from the grain elevator to the barge terminal.

A limited amount of information is available in the literature on highway construction and maintenance costs. One study indicates the highway resurfacing and maintenance cost per bushel transported. All the cost data are for the early seventies and are out of date. An updating could be done by contacting the various State highway departments.

Truck capacities may be more flexible than other modes, at least in terms of adding new equipment. One would not expect a long-term shortage of trucks unless government places further restrictions on entry into the trucking industry.

Minnesota has some highway capacity restrictions during two months in the spring. Areas of southern Minnesota seem to face more highway capacity constraints than the rest of Minnesota. How much bridges, narrow roads and the spring road restrictions limit truck travel is not clear. What is needed is an analysis of these bottlenecks to determine their impact on commodity shipments.

Finally, grain truck regulation and licensing have restricted the capacity of Minnesota grain trucking. Whether this is a serious problem is not clear. However, the State should strongly resist any further drift towards regulation of either rates or entrance into trucking.

Pipeline Costs

Pipelines are the lowest cost mode for moving large quantities of liquids or gases over fixed routes. Under favorable conditions, they are the lowest, or at least a very competitive mode, for moving solids such as coal or sulfur in an emulsion.

Economies of scale are very important in pipeline economics, as both fixed and operating costs per unit decrease rapidly as the size of the pipeline increases to a diameter of 30 inches or more (assuming the line is operated near capacity).

Average revenue per ton-mile for oil pipelines in the U.S. in 1972 was .29¢ per ton-mile. Estimates of operatings costs of large oil pipelines are .1¢ per ton-mile. These costs are lower than all other modes but are based on moving large quantities over fixed routes.

Coal pipelines are a low cost mode under specified conditions but cannot compete with barges as long as free use of the waterways is allowed.

Short, moderate volume coal pipelines generally cannot compete with existing railroad facilities but may be price competitive if significant new railroad construction is required.

Long, high volume coal slurry pipelines may be price competitive with existing railroads and are likely to be price competitive where new rail construction is required in rough terrain.

Minnesota has a shortage of effective petroleum capacity. The existing products pipelines can only supply about half of the state's needs when operating at capacity. The Lakehead crude petroleum pipeline could more than support the Minnesota refineries, but it is supplied from Canadian oilfields. Available supplies of Canadian crude have been reduced and are scheduled to be phased out completely. Although alternative sources of petroleum have been proposed which would use the Lakehead pipelines, there is an immediate requirement for crude oil transport, which will probably be supplied by barge for several years.

Auxiliary Costs and Capacities

The handling function (unloading, storage, and loading) is an important element in the transportation system. This element should be considered in analyzing intermodal competition in transporting bulk commodities. Existing information is inadequate for determining storage and handling capacities and associated costs involved in transporting most bulk commodities.

Grain is the only commodity studied for which information on storage and handling costs was available. The U.S. Department of Agriculture published data on handling and storage costs for country, inland terminal, and port terminal elevators. These studies are based on 1971-72 surveys. The studies estimate book and replacement costs for loading and unloading associated with different transport modes. Other studies have estimated grain handling and storage costs for specific elevator types or specific regions.

This information can be revised and updated to determine handling and storage costs associated with country elevators involved in grain movement through the Upper Mississippi River Basin.

However, because of changes in technology and in export and price levels, current information is not adequate to determine storage and handling costs for other elevator groups: port terminals, river terminals, and elevators with multiple rail-car loading facilities. For these groups, which included fewer elevators handling greater volumes, synthetic facilities would likely have to be constructed and analyzed. Such an analysis would necessitate the cooperation of people in the grain industry and in the elevator construction and equipment industries.

Handling and storage cost data for other commodities could also be best determined by constructing synthetic facilities. These analyses would be less complex than that for grain, because the shipping patterns are less complex and the types of facilities are more uniform.

Information is available from state and federal licensing agencies to determine grain storage capacities for elevators in the study area. No information is available on handling (loading, elevating, and unloading) capacities, however. It does not appear that grain handling capacities are a constraint to the transportation of grain in Minnesota. Further research concerning handling capacities and their effect on modal alternatives might be necessary in analyzing intermodal competition.

Handling and storage capacity data associated with coal transportation are not available. The coal movement pattern is changing dramatically in the St. Paul District as the source of coal changes from southern Illinois to Montana and Wyoming. With this change has come unit train movement of low sulfur Western coal into Minnesota. Some of this coal is being transshipped to barges for delivery to riverside users. There is a potential for considerable downward movement of transshipped Western coal down the Mississippi from St. Paul. However, the future structure of coal movement and hence the coal handling and storage needs in the Upper Mississippi River Basin are dependent upon future legislative and judicial decisions on topics such as strip mining and development of large transshipment facilities.

Intermodal Cost Comparisons

Estimating costs of producing any good or service is fraught with many problems, and estimating transport costs is no exception. Consequently, making intermodal cost comparisons may not be very meaningful. Each shipment must be considered in terms of such things as product characteristics, distance, and existing facilities.

Costs per ton-mile vary with distance and type of equipment within a single mode. These differences within a mode may be greater than the differences between modes. The lowest cost mode for a short distance and/or low volume shipment may be different from the lowest cost mode for a long distance and/or high volume shipment of the same commodity.

The lowest cost movement is frequently intermodal rather than intra-modal. The flexibility of motor vehicles and the ubiquity of the highway system cause trucks to be used in the assemby and/or distribution of commodities that are shipped most of the distance on other modes. Availability of terminals and their respective handling costs can be a major consideration in determining the least cost mode or modes.

In general, it is probably safe to say that: (1) trucks are not competitive with rail or barge for low value bulk commodities over long distances, although frequently important in assembly and delivery, (2) unit trains provide low cost for hauling bulk commodities long distances, and (3) the lowest costs per ton-mile are available from pipelines and waterways -- both of which are limited to fixed locations.

Energy and Environmental Concerns

The transportation industry generally is not an efficient user of energy. Only 20% of the energy consumed in transportation is utilized productively, compared to over 50% in some other industries.

The long haul unit train is the most energy efficient type of bulk commodity transport. The energy consumed by a 30,000 ton, 200 car, 25 m.p.h. unit train is estimated at 330 BTU's per ton-mile.

Other energy efficient modes are water, intercity trains and pipelines. Estimates of the energy requirements of these 3 modes are clustered between 450 BTU's and 600 BTU's per ton-mile, with some disagreement as to which is most efficient.

Trucks use 4 to 5 times as much energy per ton-mile (2800 BTU's) as the above modes.

Route circuitry must be considered in determining the most energy-efficient mode. All modes exhibit some circuitry, with water generally being the most circuitous and pipelines the least.

Air pollution is generally proportional to energy consumption, but the percent of transportation air pollution caused by bulk commodity transport is quite small. In addition, much of the fuel is consumed in non-urban areas where air pollution is not a serious problem.

Diesel fuel is the energy source for most bulk commodity movements, regardless of mode. No major shifts to other fuels or energy sources are forecasted for the near future.

Historical Movements

There is a notable lack of data concerning the historical movement of bulk commodities, by mode, in the St. Paul District. Information appears to be available to allow an analysis of barge movement. However, data covering bulk commodity transport by truck, rail and pipeline is deficient.

Data is available on annual barge movement, by commodity, to and from river ports above Locks and Dam 2 on the Mississippi River and ports on the

Minnesota, Black and St. Croix Rivers. Further research will be needed to determine the movement of bulk commodities by barge between Locks and Dam 2 and Locks and Dam 10 in the St. Paul District.

Grain is the most important commodity group, in terms of volume, moved by barge in the District. Grain dominates the South-bound barge movement. Most of this grain is destined for Gulf port elevators for export. The historical trend in barge grain movement has been a steady increase in volume. In 1973 total barge shipments of grain were 5,436,808 tons.

Coal has been the major commodity, volume-wise, received in the District. Coal has historically moved up the River from mines in southern Illinois. The major users have been utilities. Coal users in the District are becoming increasingly dependent upon coal from Montana and Wyoming. This low-sulfur coal is more acceptable environmentally.

Coal volume on the River has been increasing steadily. Since 1970, however, an increasing share of coal movements in the District has been coal coming from the West and transshipped to barges for delivery to users in the Twin Cities area. Such shipments have increased from 11,000 tons in 1970 to 643,500 tons in 1973. Total receipts of coal in 1973 were 2.2 million tons, down from 2.6 million tons in 1970.

A significant volume of refined petroleum products moves on the river system within the St. Paul District. The majority of the movement is up-bound, with gasoline being the dominant single commodity in the group. The trend in this movement has been one of slow growth, although 1973 saw a slight decline to a volume of 1.65 million tons.

All crude oil enters Minnesota by pipeline, with a great deal passing through the state. The total crude received at state refineries has been increasing steadily between 1960 and 1973, with approximately 10 times more coming from foreign sources (mainly Canada) than domestic production. In 1973 state refineries received 64,600,000 barrels of foreign crude and 6,000,000 barrels of domestic crude.

Movement of chemicals and allied products on the River has been increasing over time. This is mainly an in-bound movement, with fertilizers being the major chemical products received. In 1973, 164,616 tons of fertilizer products were received at river ports in the Twin Cities area.

Information on historical movement of bulk commodities by rail and truck for the study area is lacking. Information is available on the volume, though not the destination, of grain shipped by rail from the Twin Cities. Data on rail and truck movements for other areas in the state is not suitable to define these movements.

Some information is available from elevator survey studies on movements from country elevators in the state to major markets. Substantial amounts move from country to terminal facilities by both truck and rail.

Further research will be needed to determine historical volumes of grain shipped by truck and rail. This information will be very difficult to obtain for the study area.

There is sufficient information available to determine historical movements of grain from Duluth-Superior by vessel. Wheat is the major grain that is shipped from these ports.

Data on historical rail coal movements into the state are not available. However, this information should be obtainable from railroads and coal users. Truck movement of coal is not considered important for this study.

Some fertilizer enters the state by rail. Further research is needed to determine the volume of this movement.

In conclusion, information on historical commodity movements by barge and pipeline are available. There are significant gaps in the data on historic truck and rail movements, however. Considerable additional research is necessary to determine these movements.

Projections

The Iowa State projections suggest modest increases in exports of feed grains, soybeans and wheat. They suggest substantial increases in fertilizer applications, which implies substantial increases in fertilizer movement.

Table 4 is a summary comparison of the River Basin Study, Kearney, Inc. report and the Adjusted MarAd projections. In making comparisons, the reader must keep in mind that the projections may differ because of differences in underlying assumptions. The projections may also differ because of differences in classifying commodities. Finally, the River Basin projections may differ from the other two because the former are based on Upper Mississippi commerce, whereas the latter two are based on all

Table 4

Comparisons of Projected Waterborne Commerce
(Mill. of tons)*

Year in Future	Comprehensive River Basin Study 1/			Kearney, Inc. Report 2/			Adjusted MarAd 2/
	Low	Medium	High	Low	Most Likely	High	
	Selected Grains 3/			Grains 4/			Grains 4/
1980	19.0	21.0	25.0	26.00	30.20	33.25	20.32
2000	28.0	34.0	45.0	32.00	42.90	45.10	29.24
2020	34.0	50.0	75.0	40.75	47.50	61.00	43.99
	Bituminous Coal & Coke			Coal			Coal
1980	8.2	9.0	10.5	7.0	8.5	8.9	10.64
2000	7.5	10.0	13.5	12.10	14.0	16.2	16.95
2020	6.5	9.0	15.0	14.00	16.25	18.20	24.57
	Petroleum & Petroleum Products 5/			Petroleum Products 6/			Petroleum Products 6/
1980	8.3	9.6	10.7	8.70	9.00	9.10	8.19
2000	11.2	15.0	19.3	11.15	13.30	20.00	8.55
2020	13.7	20.0	28.7	13.70	19.30	24.25	8.91
	Chemicals 7/			Chemicals 8/			Chemicals 8/
1980	9.7	11.6	14.3	7.60	8.10	9.00	7.93
2000	16.8	23.3	33.3	17.00	20.80	22.00	13.88
2020	24.6	38.2	59.5	37.30	39.40	48.00	26.22

* Projections for iron and steel; cement, stone, sand and gravel (mining); all others are no included as these categories are relatively minor.

1/ Commerce on Upper Mississippi River -- the section of the river from Cairo, Illinois at the mouth of the Ohio River to Minneapolis, Minnesota.
2/ Commerce going through Locks 26.
3/ Principally corn, wheat, soybeans, but includes rye, barley, oats, inedible vegetable oi
4/ Corn, soybeans, wheat.
5/ Gasoline, gas oil, dist. fuel oil, crude petroleum, jet fuel, kerosens, resid. fuel oil, petroleum asphalt, lub. oils and grease, naphtha, other.
6/ Residual fuel oil, gasoline, distillate fuel oil, other.
7/ Industrial: Coal tar, benzol, sulphuric acid, alcohols, sodium hydroxide, pigments, pa varnishes. Agriculture: Nitrogeneous fertilizer, phosphate rock, superphosphate, potash fertilizer materials.
8/ Industrial: Alcohols, sodium hydroxide, crude coal tar, gas products. Agriculture: Ni geneous fertilizer and superphosphates.

commerce going through Locks 26.

In some instances, the projections from the separate studies are very close in the near term but deviate considerably in the longer term, and in some instances the opposite occurs. In other instances, the projections are very close over all future years.

For grain, projections for 1980 range between 20 and 30 million tons and for 2020 between 44 and 50 million tons.

For coal, the 1980 projections vary between 8.5 and 10.64 million tons and for 2020 between 9.0 and 24.57 million tons.

For petroleum, the projections range from 8.19 to 9.6 million tons in 1980 and from 8.91 to 20.00 in 2020.

Because of the uncertainty with respect to future energy policy and energy developments, longer term projections can be expected to vary considerably. The longer term projections for both coal and petroleum show considerable variation relative to the near-term projections.

For chemicals, 1980 projections vary from 7.93 to 11.6 million tons, while 2020 projections range from 26.22 to 39.40 million tons. All three projections here suggest large growth.

Conclusions

Several important questions remain unanswered or only partly answered concerning future movements of bulk commodities on the Mississippi. First, will the exports of grain continue to grow, and what will be the St. Paul District's contribution to these export demands? Second, what will be the impact on transportation of the shift in energy demands to western coal? Third, will there be a slow down in the growth in demand for agricultural chemicals due to environmental concerns or higher prices? Fourth, will the financial problems of the railroads limit their ability to respond to increased quantities of bulk commodities? Finally, are there some basic shifts occurring in the share of commodities shipped by different modes?

The outlook for continued growth in grain exports seems to be good. However, with this growth there seems to be a high probability of greater year to year fluctuations. This could have a substantial impact on transportation needs, with approximately 20 percent of the U.S. corn, 50 percent of the U.S. soybeans and 2/3 of the U.S. wheat exported. Both corn and soybean exports are currently an important market for Minnesota's grain production. Thus, what happens to foreign markets will directly affect the production and transportation needs of the region. There has also been a shift to more on-farm storage of grain. Heavy grain sales by farmers at certain times of the year could cause transportation capacity problems.

Probably the biggest uncertainty in transportation needs is for energy supplies. Traditionally, coal has come up the Mississippi from Illinois and oil has come from Canada by pipeline. The future appears to call for much more coal from the West and more movement of oil from the South. However, the modes and routes by which these new sources of energy will move is still uncertain, although, if available, water transport will be very important for at least the next several years.

One of the fastest growing commodity groups transported on the Upper Mississippi has been agricultural chemicals. Yet there are some reasons to expect this growth to decline. Prices of fertilizers have risen rapidly over the past few years, although increased supplies have recently caused price drops. Environmental quality considerations may also limit increase in the applications of fertilizers and insecticides.

The problems of the Rock Island line and the general decline in the capital stock of railroads raises important questions about railroad capacities. Can innovations such as the unit train help meet the needs for grain and coal shipments? Or will lack of capital and government regulation keep rail cost high and service low? Private ownership of hopper cars by major shippers may provide some of the needed rolling stock capacity, but well maintained road beds capable of carrying unit trains also have to be financed.

Finally, many of the projections of future waterborne shipments on the Upper Mississippi have assumed constant shares among modes. Energy shortages and/or new transportation methods (unit trains) could change the past trends in bulk commodity movements.

The answer to these questions will depend, in part, on the availability of the Mississippi River for transporting bulk commodities. Closure of the

9-foot channel would mean transporting more bulk commodities by other modes. In addition, the Upper Mississippi Basin would have to adjust consumption and production patterns to a more limited and higher cost transportation network.

Which modes and routes will handle the greater volume is not clear. However, there are a number of alternatives that should be studied to determine the impact on transportation costs and capacities of the 9-foot channel closure. These routes include: (1) rail to Chicago, the East coast, the West coast or the Gulf, (2) rail to St. Louis and barge to the Gulf and (3) by truck or rail to Duluth. To study these alternative routes more analysis and data will be needed concerning; terminal costs and capacities; rail costs and capacities; and the likely quantities imported and exported from the region.

The impacts on the Upper Mississippi Basins's consumption and production patterns will be even more difficult to determine than the impact on other transportation modes. At one extreme would be a fairly major shift from a grain exporting region to a livestock exporting region; heavier dependence on coal and nuclear energy, and a reduction in the use of some agricultural inputs. At the other extreme would be some minor increases in transportation costs, which would mean lower net prices for farmers and higher prices of energy and other imported commodities for consumers.

Other Issues

The optimum location of future river terminals depends on the origin or destination of the commodity and the existing or required land transportation facilities as well as environmental considerations. Information is available to determine such things as the differences in total transport costs between proposed locations. However, highways to support new terminals will have other major effects, especially if they encourage development in new areas.

Information on docking and fleeting requirements, both present and future, is not available in the literature. Neither bench marks nor rules of thumb to tie fleeting needs with projected volumes were found. This information will have to be obtained from operator estimates and the examination of historical ratios and past operating practices.