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John Barton, Stanley K. Seaver and William J. Hanekamp*

INTRODUCTION

The New England livestock industry obtains 99 percent of its feed corn requirements from midwestern origins, mainly Ohio, Michigan, and Indiana. Because of the distances involved, transportation costs represent a significant portion of the price of corn delivered to mixing plants. In addition, the poultry industry in the Southeast, which competes in the same product market as New England, enjoys lower transportation rates for corn shipped from the Midwest.[1] Because of rapidly rising rail rates and a widening gap between rates to New England and the Southeast, it is important to investigate the economic feasibility of an alternative transport mode.

Water transportation has long been considered a potentially viable alternative to rail shipment of grain to New England. Although water transport feasibility studies have been made for the Northeast, none have approached the scope or level of detail of this report. The Eastman Study made in 1957 concluded that the investments required in terminal receiving facilities would wipe out any potential savings from water movement. In 1964 the Booker Study was conducted to determine the feasibility of developing pier facilities in Rockland, Maine, an integral part of which would involve corn shipments. While the study showed the operation to be profitable, costs incurred in its initiation and subsequent cost over-runs resulted in the failure of the project. In 1971, G.W. Fauth and Associates, on behalf of the Water Transport Association, investigated the feasibility of shipping grain to Buffalo in self-unloading vessels and then to New England in 100 car-unit trains.

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1 Stanley K. Seaver and William J. Hanekamp, "Recent Developments in Feed Transportation to New England," Storrs Agricultural Experiment Station, Research Report 48, December 1977.

This study develops total cost figures for a water transport system which would supply New England's total feed corn requirements. Within this broad objective, the sub-objectives are to:

1. Locate potential receiving ports in New England.
2. Determine costs of water transportation from origins to potential port sites.
3. Determine costs of receiving and handling operations at potential port sites.
4. Determine truck distribution costs from receiving sites to feed mixers.
5. Identify least-cost shipping patterns which minimize total barging, handling, and trucking costs.
6. Compare present and projected costs of a water transport system with present and projected rail rates to determine the actual or potential viability of water transportation as a competitive mode.

POTENTIAL SHIPPING PATTERNS

As a basis for analyzing the costs of a water transportation system, potential shipping patterns must be developed. Specifically, the source(s) of corn, the ports where the corn can be handled, and the location and demand volumes of feed mixing plants must be identified and described. Of these, only the feed mixing plants are predetermined. Potential transhipment points will consist of a fixed number of ports in New England which would be able to accommodate grain handling operations of the magnitude required by New England's corn demand. The potential sources of corn for water shipments will be ports with existing vessel or barge loading facilities. Since there are presently no large volume domestic intracoastal grain shipments, only the major export facilities will be considered.

Sources of Corn

A primary consideration with respect to corn sources is the purchase price of corn at the point where the barge is loaded. If corn buyers must pay more for corn shipped by water then by rail, the price differential would be considered a "cost" of water transportation. In order to calculate this differential, prices for corn shipped by rail and prices at potential barge loading points must be determined.

Presently, nearly all of the corn shipped to New England originates in Ohio, Indiana, and Michigan. Because these states constitute the nearest major surplus area, prices in this region have the greatest influence on prices in New England.

For the purposes of this study, it would be realistic to consider price at a point where large volumes of corn are assembled for shipment out of the region. Toledo, Ohio presently supplies a major portion of the corn shipped by rail, and is a major foreign export port with substantial handling and transfer facilities. The Toledo wholesale price was assumed to be the price which New England corn consumers presently pay at origin for corn shipped by rail.

Possible origins of corn shipped to New England via water routes would be Houston, New Orleans, Norfolk, Baltimore, and Toledo. Corn can be shipped from Toledo to New England via either the St. Lawrence Seaway or the New York State Barge Canal. Because of the great distances involved and the amount of investment which would be required for additional barging equipment, shipping corn from Toledo via the St. Lawrence Seaway and from gulf ports were not considered in this study.

Because cold weather closes lake and canal shipping during the period from December 1 to April 15, shipments from Toledo are limited to the seven and a half months the canal is open. Shipments from the Atlantic ports, however, are not restricted by weather factors.

Corn prices at Baltimore and Norfolk are approximately equal, but since Norfolk is closer to New England than Baltimore in terms of barging time, Norfolk alone was considered. The corn sources investigated in this study, therefore were Norfolk, Virginia, and Toledo, Ohio (via the New York State Barge Canal). The prices paid by domestic corn consumers at these export markets will be used as the price of corn shipped by water.

Transhipment Points

Since the primary function of the receiving site is to transfer grain from one transportation mode to another, the size of the transhipment handling facility would be fixed by technical constraints of transfer operations. It will be shown in a later section that economies in barging operations require enough storage capacity to unload a barge in a limited amount of time. Economies of scale in grain storage per se, therefore, need not be considered.

The following port locations were considered to be potential sites for grain handling facilities: St. Albans and Burlington, Vermont; East Hartford, Portland, New London and Norwich, Connecticut; Providence, Rhode Island; Boston, Massachusetts; Portsmouth, New Hampshire; Portland, Bath, and Winterport, Maine. The primary criteria for selection of potential receiving ports were 1) the availability of enough water depth to handle barges of the size required, and 2) the proximity to demand areas. Bridgeport, Connecticut, for example, satisfies the first requirement, but is located in the southwestern portion of the state, away from the major feed mixers. In this case, New London would immediately force Bridgeport or New Haven out of the solution. Rockland, Maine, although located close enough to demand areas to be considered a potential transhipment point, lacks the depth required to accommodate ocean barges.

Not all of these ports can be serviced by both Toledo and Norfolk shipments due to physical limitations of both barge operations and port facilities. Specifically, the New York State Barge Canal limits the size of barges to 300' in length and 15' of draft.[2] Because barges of this size are not seaworthy shipments from Toledo would be limited to the Lake Champlain, Connecticut River, and Thames River waterways, all of which have approximately 15' of water. Shipments from Norfolk in large ocean barges require approximately 27' of water[3] and would therefore be limited to the deep water ocean ports from New London, Connecticut, to Winterport, Maine. New London is the only port which would be able to receive shipments from both origins.

The least cost shipping pattern for the Connecticut area could be determined by simultaneously considering both Norfolk and Toledo as corn sources. However, because of differences in barge unloading equipment, it would be economically infeasible to receive both types of barges at the same port. Other fixed cost considerations and the seasonal nature of Toledo shipments also support a separate examination of the two sources.

Demand Points

The volumes of corn demanded by feed mixers is fairly constant since annual fluctuations in the number of livestock units in the region are small. Estimates of weekly corn demand for New England mills are given in Table 1 and demand points are shown in Figure 1. Grain received at port sites would be transported to mills by truck. It is assumed that present corn storage patterns at feed mills would not change under a water transport system.

Table 1. Weekly Corn Demand of Major New England Feed Mixers.

Feed Mixer	Weekly Volume (tons)	Feed Mixer	Weekly Volume (tons)	Feed Mixer	Weekly Volume (tons)
1	194	11	560	21	462
2	116	12	350	22	1500
3	200	13	674	23	115
4	1212	14	346	24	702
5	500	15	683	25	170
6	240	16	827	26	292
7	650	17	962	27	85
8	377	18	296	28	810
9	1050	19	1731	29	75
10	232	20	315		

2 Mr. Norman Blumstein, U.S. Army Corps of Engineers, N.Y., N.Y. Telephone interview, December, 1976.

3 Letter from S.C. Loveland, III., S.S. Loveland Company, Inc., Philadelphia, Pennsylvania, August 31, 1976.

Figure 1. Geographic distribution of major feed mixers in New Ennland

METHODOLOGY

From the potential shipping patterns outlined in the preceding section, least cost shipping patterns which minimize total assembly, handling, and distribution costs were determined. With corn sources and final demand points fixed, the variables which determine total costs are the number and location of receiving facilities. The least cost solution will therefore identify the facility location pattern and the quantities of corn to be handled at each port.

There are five potential receiving ports for shipments from Toledo and seven for shipments from Norfolk. With five and seven receiving ports there would be 31 and 127 possible location patterns, respectively. In actual fact the number of location patterns can be dramatically reduced. The reason is that the costs of distributing corn by truck are high compared with other costs and rise rapidly as distance from the receiving port increases.

With respect to shipments from Toledo, trucking costs would prohibit ports in Connecticut supplying Vermont and vice versa. Vermont and Connecticut, with two and three potential ports respectively, actually constitute two separate problems.

Similarly, for shipments from Norfolk, the region's demand can be divided into two subregions; Maine and Southern New England. Separate solutions were obtained for the Southern New England region, with New London, Providence, Boston and Portsmouth as potential receiving ports, and the Maine region, with Portland, Bath, and Winterport as potential receiving ports. No attempt was made to determine the costs of shipping corn from Norfolk to Vermont.

COST ESTIMATES OF NORFOLK SHIPMENTS TO SOUTHERN NEW ENGLAND AND MAINE

Because of major differences in barging systems, total costs for Norfolk and Toledo shipments were developed separately. In both cases, total costs included three components: assembly costs, which are costs associated with delivering corn to the receiving port; handling costs, which include the costs of receiving, storing, and loading corn into trucks; and distribution costs, which consist of trucking costs from facility sites to feed mixing plants. Norfolk shipments will be considered in the first section, and Toledo shipments will be considered in the second section.

Assembly Costs

Assembly cost consists of two components: the differential between the price of corn at the Norfolk elevator and the price of corn at midwestern elevators (from which corn is presently shipped to New England by rail); and the water transportation cost to New England ports.

Corn Price Differential. Eastern North Carolina and Virginia do not produce sufficient surplus corn to meet New England's requirements. Because of limited local supplies, corn at Norfolk must be shipped by rail from midwestern origins. Cincinnati, Ohio, is the market center nearest to Norfolk. The corn price in Cincinnati plus the rail rate to Norfolk should approximate the price at the export elevator.

No published wholesale corn prices are available for Cincinnati, but daily average prices paid to farmers in southwestern Ohio are reported. Both wholesale prices and prices paid to farmers were available for the Toledo area. Toledo wholesale price was regressed on the price paid to farmers in northwestern Ohio with the following results:

$$\text{Toledo wholesale price} = 5.892 + 1.05 \text{ pp } (32.662),$$

where pp is price paid to farmers and the T-value is shown in parentheses.

Prices paid to farmers in southwestern Ohio were substituted into the above formula to obtain monthly Cincinnati wholesale prices. In comparing Toledo and Cincinnati wholesale prices, the Cincinnati price was higher by an average of 5.2¢ per bushel or $1.86 per ton. This $1.86 per ton above the price paid for corn shipped directly by rail from Toledo is considered part of the assembly cost.

In addition to the price differential, the cost of shipping corn by rail from Cincinnati to Norfolk must be considered. The applicable domestic three car rate was $15.00 per ton.[4] Handling charges for loading barges at Norfolk would be approximately 4¢ per bushel or $1.44 per ton.

The total price differential between corn loaded into barges at Norfolk and corn loaded into rail cars at Toledo, therefore, would be the Cincinnati-Toledo price differential ($1.86) plus the rail rate from Cincinati to Norfolk ($15.00) plus the handling charge at the Norfolk port elevator, ($1.44) or approximately $18.30 per ton.

Barging Costs. Ocean barge rates are neither published nor regulated. Since there are no large volume grain shipments between U.S. ports, it was necessary to develop barging costs from general cost data.

The two largest costs of barging operations are towing charges and barge depreciation costs. Towing charges for ocean tugs are quoted on a per diem basis. There are presently no barges on the east coast suitable for large volume corn movements, so annual depreciation costs must be based on the construction of new barges.

Barging costs per ton are affected by three interrelated factors: barge size, barging time from origin to destination, and the annual volume of corn transported. Since the latter two factors are considered fixed, barging costs to New England ports will depend upon the size and number of barges to be used. At one extreme, a single 25,000 ton barge could move the region's entire an-

4 Obtained from M.R. Resnik, Rate Department, Norfolk and Western Railway, Norfolk, Virginia, May 1977.

nual volume. At the other extreme, many 3,000 ton barges could be used. Because of minimum charges for tug services, however, smaller volume movements involving several barges would be uneconomical. The most efficient barging system based on annual volume of corn shipped would involve two barges of roughly equal size.

New England's corn demand can be divided between two sub-regions, Maine and southern New England, whose annual corn demands are approximately 420,000 and 300,000 tons, respectively. At these rates of demand one barge would be required to service each sub-region. At 13 days round trip time from Norfolk to Maine, 448,000 tons could be shipped using a 16,000 ton barge, assuming constant utilization. Based on barging time, corn requirements, and economies of barging operations, a 12,000 ton barge could most efficiently service southern New England.[5]

Barging cost, which includes depreciation and maintenance, plus towing charges, are affected by the unloading method because of the expense associated with longer unloading periods. Hence, it was necessary to determine total unloading costs associated with different types of equipment.

Portable evacuators and simple clamshells on cranes were not considered because of low unloading rates. Three unloading systems were considered: large overhead clamshells (dock installed) which move grain to a conveyor system; a totally enclosed boom system (dock installed) which is lowered into the hold and conveys grain vertically into a silo; and a self-unloading system, installed in the barge itself, which uses screws in the bottom of the holds and elevators to move grain to dockside conveyors. Total investment and operating costs associated with the overhead clamshell and the enclosed conveyor are shown in Appendix A tables 1 and 2. However, the self-unloading system can unload corn at a much faster rate and thereby reduce unloading time. Since tug charges apply whether or not the barge is moving, prompt unloading is necessary to hold down barging costs. At $6,000 per day for tug service, each additional day required to load and unload increases barging cost by $.38 per ton on a 16,000 ton shipment. Because of this, the combined barging and unloading costs were substantially lower for the self-unloading mechanism. Self-unloading barges were therefore considered in this analysis, and, for simplicity, unloading costs were considered to be part of the barging cost.

Having determined the lowest cost barging and unloading system, barge rates were developed from annual depreciation and operating costs, daily tug charges, and round trip barging times to ports. Annual depreciation and operating costs for the 12,000 and 16,000 ton self-unloading barges would be $1,073,350 and $1,189,400, respectively, as shown in Table 2.

Barge rates were calculated on the basis of barging time and number of trips required. For example, the round trip time to Bath is 13 days based on an

5 With a round trip time of approximately 10 days, only 8,000 tons capacity would actually be necessary if the barge were used continuously. However, the additional towing costs resulting from a greater number of required trips is higher than the increase in fixed and operating costs of a 12,000 ton barge.

Table 2. Annual depreciation and operating costs for self-unloading 12,000 and 16,000 ton barges.

	12,000 ton	16,000 ton
	(Dollars)	
Barge construction cost[a]	3,400,000	4,000,000
Unloading system cost[b]	3,500,000	3,600,000
Total investment cost	6,900,000	7,600,000
Annual equivalent cost (15 year expected lifetime)	907,350	999,400
Barge maintenance and repair[a]	105,000	120,000
Hull insurance[a]	51,000	60,000
Unloading system maintenance and repair[b]	10,000	10,000
Total annual cost	1,073,350	1,189,400

a Mr. Emmett Butler, Wyllys Barge Lines, Inc., Paulsboro, New Jersey, telephone interview, December, 1976.

b Mr. Bob Bodnar, Orba Corporation, Fairfield, New Jersey, telephone interview, January, 1977.

average speed of 7 knots with 4 days allowed for port waiting and loading and 1 day for unloading. In a year, 27 trips to Maine would be required to ship 420,000 tons. The barge would therefore be used 27 x 13 or 351 days. Dividing the annual operating costs by 351 gives a daily barge cost of $3,389. Adding the daily towing charge of $6,000[6] results in a daily shipping cost of $9,389. Multiplying this by the round trip time (13 days) to Bath and dividing by 16,000 tons will give the barging cost per ton. Adding 15 cents unloading cost for labor and power results in a transport cost of $7.78 per ton.[7]

For southern New England, twenty-eight round trips would be required to ship 331,000 tons of corn in a 12,000 ton barge. The round trip time to New London, for example, is 9.5 days so that the barge would be in use 266 days. Dividing total annual cost of $1,073,350 (Table 2) by 266 results in a daily barge depreciation and operating cost of $4,035. Towing charges are $5,500[8] or a total daily cost of $9,535. Dividing the total round trip cost ($90,582) by

6 Mr. Paul Quinn, Moran Towing and Transport Inc., telephone interview, February, 1977.

7 The transport cost is $7.66 to Portland and $8.07 to Winterport. Even though Portland has lower transport costs, the distribution costs are much higher than for Bath.

8 Mr. Paul Quinn, **op. cit.**

12,000 tons and adding 15 cents for unloading costs results in a total barging cost of \$7.70[9] per ton.

Handling Costs at Receiving Ports

Annual Fixed Costs. The primary function of port handling facilities is to transfer corn from barges to trucks. Given that barge size is fixed, storage facilities need be no larger than necessary to receive a single barge load of corn and maintain a reserve supply to cover shipping delays. The minimum storage capacity required would be based on the trade off between the costs of having the barge itself serve as a storage facility and the costs of building enough storage capacity to unload the barge immediately. In actual fact, tug costs associated with idle time in port far outweigh the costs of building storage capacity.

Handling facilities in the Maine sub-region would therefore require 16,000 tons capacity for barge unloading plus approximately 3,600 tons reserve capacity for a total of 19,600 tons, or about 700,000 bushels. Facilities in southern New England would require 500,000 bushels of storage capacity, which would include 12,000 tons capacity to accommodate barge unloading plus about 2,000 tons of reserve capacity.

Construction costs for receiving facilities of 500,000 and 700,000 bushels storage capacity are presented in Appendix A, Tables 3 and 4. The fixed costs of plant and equipment, including site costs are summarized in Table 3.

Annual Variable Costs. Variable costs are composed of labor costs, maintenance and repair, and power costs. Labor costs are by far the largest of

Table 3. Summary of Annual Fixed Costs for 500,000 and 700,000 Transhipment Facility.

Cost	500,000 bu. New London, Ct. (Dollars)	700,000 bu. Bath, Me. (Dollars)
Silos and equipment	217,441	259,705
Taxes and insurance	59,760	72,720
Port site	36,000	23,045
Total Annual Fixed Costs	313,201	355,470

9 The other ports considered were Providence, Boston and Portsmouth with barging costs per ton of \$8.23, \$9.21 and \$9.78 respectively.

the three. In order to calculate labor costs per ton for different volumes of corn handled at different ports, labor specifications and productivities were estimated assuming divisibility of labor inputs. This assumption is not unrealistic given job substitutability and part-time work. Barges are only unloaded approximately every two weeks and unloading labor could be drawn from other job specifications.

Labor requirements and costs for the 500,000 bushels (handling 311,000 tons) and the 700,000 bushels (handling 412,000 tons) facilities are developed in Appendix A, Table 5. Fixed and variable costs per ton are summarized in Table 4.

Distribution Costs

Truck distribution costs from ports to mills in southern New England are shown in Table 5 and for the Maine region in Table 6. The formula used to generate these estimates appears in Appendix B.

Table 4. Cost Summary for 311,000 and 412,000 Ton Transhipment Facility

	New London, Ct.		Bath, Maine	
	Dollars per ton			
Variable Costs				
Labor	.32		.28	
Maintenance and repair[a]	.11		.10	
Electricity and heat	.08		.07	
Other (supplies, telephone)[a]	.04		.03	
Total Variable Costs		.55		.48
Fixed Costs[b]				
Annual equivalent costs				
Plant and equipment	.66		.63	
Taxes and insurance	.18		.18	
Port site cost	.11		.11	
Total Fixed Cost		.95[c]		.87[c]
Total Operating Cost		1.50		1.35

a The costs are based on estimates available from William J. Hanekamp's unpublished unit train facility study.

b Fixed costs per ton are based on annual equivalent costs shown in Tables 4 and 5.

c The variable costs for the Maine ports would be the same as for Bath and the other ports would be the same as New London. The fixed cost per ton was $.96 for Providence, $.95 for Boston, and $.97 for Portsmouth. For Winterport the fixed cost per ton is $.88 and for Portland $.99.

Table 5. Distribution Costs from New London, Connecticut.

Mixing Plant	Mileage	Road[b]	Cost	Annual Corn Volume	Annual Costs
	(One-way)		(Dollars per ton)	(000's tons)	(Dollars)
1	85	—	4.60	11	50,600
2	85	—	4.60	6	27,600
3	35	X	2.00	10	20,000
4	20	X	1.25	63	78,750
5	20	X	1.25	26	32,500
6	5	X	.75	12	9,000
7	95	—	4.90	34	166,600
8	130	—	6.80	20	136,000
9	50	X	2.55	55	140,250
10	110	—	5.35	12	64,200
11	145	—	7.30	29	211,700
12	160	—	7.55	18	135,900
13	125	—	6.70	35	234,500
Total				331	1,307,600
Average Cost Per Ton			3.95[a]		

a Distribution costs from Providence, Boston, and Portsmouth, the three alternatives evaluated were $4.07, $4.11, and $6.26 per ton respectively.

b X is undivided road (30 mph).

Table 6. Distribution Costs from Bath, Maine.

Mixing Plant	Mileage	Road[b]	Cost	Annual Corn Volume	Annual Cost
			(Dollars per ton)	(000's tons)	(Dollars)
14	30	Y	1.90	18	34,200
15	35	X	2.00	35	70,000
16	40	Y	2.25	43	96,000
17	45	X	2.35	50	117,500
18	45	X	2.35	15	82,250
19	50	Y	2.65	90	238,500
20	60	Y	3.20	16	51,200
21	65	X	3.25	24	78,000
22	85	—	4.60	78	358,800
23	35	X	2.00	6	12,000
24	60	Y	3.20	37	118,400
Total				412	1,257,600
Average Cost Per Ton			3.05[a]		

a The ports of Portland and Winterport were evaluated and distribution costs per ton were $3.31 and $3.34 respectively.

b X is undivided road (30 mph). Y is divided road (45 mph).

Summary of Norfolk Shipments

Shipments by barge from Norfolk would be received at New London, Connecticut and Bath, Maine since these two ports have the lowest total cost per ton compared to several other alternative ports considered. From New London, Connecticut distribution would be to feed mixers in eastern Massachusetts, southeastern New Hampshire and one plant in southern Vermont. Bath will service eleven mixing plants, all located in Maine.

There are four important cost elements, namely costs associated with moving corn from mid-west origins to Norfolk, and barging, handling and distribution costs. The summary for all ports considered is shown in Table 7.

Table 7. Summary of Cost Components for Shipments from Norfolk.

Ports	Price[a] Differential	Barging[b]	Plant[c] Operation	Distribution	Total
	Dollars per ton				
Central and Southern New England					
New London	18.30	7.70	1.50[c]	3.95	31.45
Providence	18.30	8.23	1.51	4.07	32.11
Boston	18.30	9.21	1.50	4.11	33.12
Portsmouth	18.30	9.78	1.52	6.26	35.86
Maine					
Bath	18.30	7.78	1.35	3.05	30.48
Portland	18.30	7.66	1.47	3.31	30.74
Winterport	18.30	8.07	1.36	3.34	31.07

a In all instances the $18.30 includes $1.86 as Cincinnati price differential over Toledo, $15.00 rail rate from Cincinnati to Norfolk, plus $1.44 handling charges at Norfolk.

b All barging costs include annual equivalent cost of barge plus daily towing charge plus $.15 per ton for unloading. Lower costs for Maine are due to economies associated with 16,000 ton barge which offset greater barging distances.

c Includes both variable and fixed cost of transhipment facility and its operation. Lower Maine costs are due to economies of scale.

COST ESTIMATES OF TOLEDO SHIPMENTS TO VERMONT AND CONNECTICUT

Assembly Costs

Prices paid for corn delivered to export elevators in Toledo are assumed to be the same as prices at subterminal elevators for rail car loading. Hence, prices for water shipments to New England would be the same as for rail shipments.

The most economical shipping mode from Toledo to Oswego, New York, where the New York State Barge Canal connects with Lake Ontario, is by 10,000 ton bulk freighter.[10] Because the Barge Canal only can handle barges of 2,200 tons or less, corn must be transferred from lake vessel to canal barge. It would be uneconomical to use the smaller canal barges on the lakes even though this would eliminate handling charges at Oswego.[11]

The procedure used to develop barging costs was the same as that used in determining barging costs from Norfolk. Costs are based on the construction of new barges (2,200 tons). Investment and operating costs are shown in Appendix C, Table 1. As was the case with ocean shipments, self-unloading equipment represents the most economical method of unloading grain because of savings in tug charges and labor costs. The use of pneumatic evacuators was determined to be uneconomical because of excessive labor costs.

The Barge Canal is open from April 15 to December 1, or approximately 225 days. Daily barge costs based on 225 days of operation are estimated at $678. Towing charges are quoted on an hourly basis at a rate of approximately $135 per hour or $3,240 per day. Daily shipping costs would therefore be $3,918 per day. Thus, barging cost per ton to Burlington would be $14.25 plus $.15 for unloading or $14.40. To Norwich the cost would be $16.92 plus $.15 or $:17.07.

Handling Costs

There are two possibilities for scheduling grain shipments from Toledo through port receiving facilities to mill operators. Because the canal route is open only seven and one-half months a year, corn may be obtained by water for consumption in the open months only, or may be shipped in during the open months at a rate which would satisfy total annual demand. The first alternative would involve a switch to rail shipments during the months the canal is closed, while the second would require storage of corn for consump-

10. Mr. Hector Marchini, Morania Oil Tanker Corporation, New York, New York, telephone interview, November, 1976.

11 **Ibid.**

tion in the closed months. Because of underutilization of both the greater number of barges and the larger storage facilities required, the second alternative can be ruled out.

If rail is used during the closed months, a port receiving facility would only need to be large enough to receive 2,200 tons plus a reserve storage of around 2,000 tons in the event of shipping delays. This would amount to approximately 150,000 bushels of storage capacity. Annual fixed costs of plant and equipment and site costs are shown in Appendix C, Table 2 for a facility which will handle 74,000 tons (Vermont) and 166,000 tons (Connecticut). Labor costs are shown in Appendix C, Table 3.

Table 8 summarizes the fixed and variable costs per ton for the 74,000 ton Vermont and the 166,000 ton Connecticut facility.

Table 8. Cost Summary for 74,000 and 166,000 Tons Transhipment Facility.

	Norwich, Ct. 166,000 Tons		Burlington, Vt. 74,000 Tons	
	Dollars per ton			
Variable Costs				
Labor	.52		.86	
Maintenance and repair	.15		.17	
Electricity and heat	.08		.10	
Other (supplies, telephone)	.05		.05	
Total Variable Cost		.80		1.18
Fixed Costs[a]				
Annual equivalent cost plant and equipment	.41		.92	
Taxes and insurance	.12		.27	
Port site cost	.10		.21	
Total Fixed Cost		.63		1.40
Total Operating Cost		1.43		2.58

a Fixed costs per ton are based on annual equivalent costs shown in Appendix C, Table 2.

Distribution Costs

Distribution costs were estimated using the method described in the Norfolk section. Mileages and costs of distribution from Norwich and Burlington are shown in Table 9.

Table 9. Distribution Costs from Norwich, Connecticut and Burlington, Vermont.

Mixing Plant	Mileage	Road[a]	Cost	Annual Corn Volume	Annual Cost
			(Dollars per ton)	(000's tons)	(Dollars)
Norwich					
3	25	X	1.50	10	15,000
4	10	Y	.90	63	56,700
5	10	Y	.90	26	23,400
6	5	X	.75	12	9,000
9	40	X	2.15	55	118,250
Total				166	222,350
Average cost per ton			1.34		
Burlington					
25	5	Z	.85	9	7,650
26	15	X	1.05	15	15,750
27	20	Y	1.35	4	5,400
28	35	Y	2.00	42	84,000
29	20	X	1.25	4	5,000
Total				74	117,800
Average cost per ton			1.59		

a X is undivided road (30 mph).
Y is divided road (45 mph).
Z is multilane road (55 mph).

Summary of Toledo Shipments

Corn shipments from Toledo to Vermont and Connecticut would move by lake freighter from Toledo to Oswego, New York. From Oswego, 2,200 ton barges would travel via the New York Canal and other waterways to their destinations. Norwich, Connecticut and Burlington, Vermont were the ports with lowest combined cost per ton and therefore the only ones presented in detail. St. Albans, Vermont was considered as well as East Hartford and Portland, Connecticut. Distribution from the lowest cost ports would be only to mixers in Vermont and Connecticut. The remainder of New England would not be a part of this plan.

Table 10 summarizes the major costs associated with operating a transhipment facility at Burlington and Norwich.

Table 10. Summary of Cost Components for Shipments from Toledo.

	Toledo to Oswego[a]	Barging[b]	Plant Operation[c]	Distribution	Total
	Dollars per ton				
Burlington	7.74	14.40	2.58	1.59	26.31
Norwich	7.74	17.07	1.43	1.34	27.58

a Includes bulk freighter of $6.12 and Oswego port costs of $1.62.
b Includes costs for barge, towing and $.15 per ton unloading.
c Includes both fixed and variable costs of operation.

SUMMARY AND CONCLUSIONS

At the time this study was undertaken, rail rates from Toledo were $20 per ton to Maine and $16.45 per ton to Vermont and Connecticut. The total costs of shipping grain by water from Norfolk to Maine and southern New England would be $30.48 and $31.45 per ton, respectively. From Toledo, total costs of water transport would be $26.31 to Vermont and $27.58 per ton to Connecticut. Based on present costs, therefore, water transport cannot compete with rail in supplying New England's corn requirements.

Using projected water and rail rate increases, the future feasibility of water transport can be assessed. Between August 1973, and February 1977, rail rates for corn to New England increased at an annual rate of 12 percent. Water transport costs can be expected to increase at an annual rate of around 9 percent for Norfolk shipments and around 7 percent for Toledo shipments. From these projections of cost increases, we could expect water transport to become competitive with rail sometime after 1990. However, there are several potential developments which would affect future cost relationships. For example, reductions in the rail rate from Cincinnati to Norfolk, which would be likely if domestic unit train service were instituted, could reduce the price paid at the Norfolk port elevators by as much as $7 per ton. Dramatic increases in corn production in North Carolina could also exert downward pressure on the Norfolk corn price.

Improvements in the New York State Barge Canal would allow shipments of 6,600 tons instead of 2,000 tons and thus reduce barging costs by as much as $5 per ton. Given institutional and other factors, however, this scenario is not likely in the near future.

Finally, it should be pointed out that the risk on the substantial investments associated with water transport must be considered a cost of switching from rail to water. Because of this, water transport costs would have to be below rail rates by some amount in order to induce the required investments. A major risk factor would be the reaction of the railroads in the face of the potential feasibility of water transportation.

In conclusion, water transport of feed grains to New England is and will be for the foreseeable future a high cost alternative to rail service. New England feed corn consumers must look elsewhere for relief from high transport costs.

APPENDIX A

TABLE 1. Unloading Costs of an Overhead Installed Clamshell.

Investment cost (dollars)[a]	
Dock foundation and clamshell	4,500,000
Annual equivalent cost (20 year expected lifetime)	528,750
Operating costs (dollars per ton)[b]	
Labor (6 workers at $8.00 per hour)	.12
Power	.10
Product shrinkage (.125%)[c]	.20
Total operating costs per ton[d]	.42
Total unloading cost (dollars per ton) at:	
100,000 tons handled per year	5.71
200,000 tons handled per year	3.06
400,000 tons handled per year	1.74

a Mr. James Bleke, LaGardeur International, Belchase, Texas, telephone interview, January, 1977.

b Ibid.

c Mr. Richard Swanson, Buhler-Miag, Inc., Minneapolis, Minnesota, telephone interview, December, 1976.

d Maintenance and repair costs not available.

APPENDIX A

TABLE 2. Unloading Costs Associated With An Enclosed Conveyor System.

Investment costs (dollars)[a]	
Dock foundation	2,500,000
Conveying unit	1,500,000
Total investment cost	4,000,000
Annual equivalent cost[b] (20 year expected lifetime)	470,000
Operating costs (dollars per ton)[c]	
Labor (6 workers at $8.00 per hour)	.12
Power	.10
Product shrinkage	——
Total operating cost per ton[d]	.22
Total unloading cost (dollars per ton) at:	
100,000 tons handled per year	4.92
200,000 tons handled per year	2.57
400,000 tons handled per year	1.40

a Mr. Richard Swanson, Buhler-Miag, Inc., Minneapolis, Minnesota, telephone interview, January, 1977.

b Because much of the cost of the system is associated with installation, scrap value is assumed to be zero.

c **Ibid.**

d Maintenance and repair costs not available.

APPENDIX A

TABLE 3. Annual Fixed Cost For a 500,000 Bushel Transhipment Facility at New London, Connecticut.

Cost Item	Years for Depreciation	Installed Cost	Annual Equivalent Cost
	(Dollars)		
Gravity pit[a]	30	30,000	3,183
Conveyors	10	150,000	24,405
Scale house[c]	20	100,000	11,750
Elevators[b]	10	250,000	40,675
Spouts, turnheads[b]	10	190,000	30,913
Silos[a]	40	625,000	63,938
Electrical, heat detection and aeration equipment[d]	10	150,000	24,405
Roadway[d]	40	80,000	8,184
Truck scale[d]	20	60,000	7,050
Office[d]	20	25,000	2,938
Total installed cost		1,660,000	
Total annual equivalent cost			217,441
Taxes and insurance (3.6% of installed cost)[d]			59,760
Port site costs			36,000
Total annual fixed costs[e]			313,201

a Mr. Thomas Smith, Hough Brothers, Inc., Sunfield, Michigan, telephone interview, September, 1976.

b Mr. James Bleke, LaGardeur International, Belchase, Texas, telephone interview, January, 1977.

c Mr. Bob Bodnar, Orba Corporation, Fairfield, New Jersey, telephone interview, January, 1977.

d Mr. William J. Hanekamp, "A Report on the Impact of Unit Train Service for Corn to New England," (unpublished research, Department of Agricultural Economics and Rural Sociology, University of Connecticut), Appendix B.

e Annual fixed cost for Providence is $317,201, for Boston $313,201, and for Portsmouth $321,251. The difference in the fixed costs is due entirely to differences in site costs.

APPENDIX A

TABLE 4. Annual Fixed Cost for a 700,000 Bushel Transhipment Facility at Bath, Maine.

Cost Item	Years for Depreciation	Installed Cost	Annual Equivalent Cost
	(Dollars)		
Gravity pit[a]	30	30,000	3,183
Conveyors[b]	10	150,000	24,405
Scale house[c]	20	100,000	11,750
Elevators[b]	10	300,000	48,810
Spouts, turnheads[b]	10	200,000	32,540
Silos[a]	40	875,000	89,513
Electrical, heat detection and aeration equipment[d]	10	180,000	29,286
Roadway[d]	40	100,000	10,230
Truck scale[d]	20	60,000	7,050
Office[d]	20	25,000	2,938
Total capital outlay		2,020,000	
Total annual equivalent cost			259,705
Taxes and insurance (3.6% of installed cost)[d]			72,720
Pier and site leasing			23,045
Total annual fixed costs[e]			355,470

a Ibid.
b Ibid.
c Ibid.
d Ibid.
e Annual fixed cost for Portland is $406,835 and for Winterport $362,425.

APPENDIX A

TABLE 5. Labor Costs for a Transhipment Facility Handling 311,000 and 412,000 Tons Annually.

	No. Employees Required		Annual Cost (Dollars)	
	311,000 tons	412,00 tons	331,000 tons	412,000 tons
Administration				
Secretarial	1	1	6,240	6,240
Clerical	1	1	7,280	7,280
Accounting	.25	.25	4,000	4,000
Ass't Manager	1	1	15,000	15,000
General Manager	1	1	20,000	20,000
Total cost			52,520	52,520
Cost Per Ton (cents)			.17	.13
Direct Labor				
Receiving	.5	.5	5,200	5,200
Shipping	2	3	20,800	31,200
Scale Weighman	.5	1	5,200	10,400
General Labor	.5	.5	4,680	4,680
Dispatcher/Foreman	1	1	12,000	12,000
Total cost			47,880	63,480
Cost Per Ton (cents)			.15	.15

APPENDIX B

METHOD OF DETERMINING DISTRIBUTION COSTS

The costs of distribution by trucks are developed from the following formula:

Average Distribution Costs =

$$\frac{TFC}{(260)\ (22)\ (m)} + w\ [(a + b)m] + \frac{W(q_i d + I) + \theta d}{22}$$

$m = 1, 2, 3, 4, 5, 6$ $\qquad$ $i = x, y, z$

where TFC = Total Fixed Cost of trucks utilized (depreciation, taxes, license, etc.)

260 = number of days of delivery service per year

22 = truck load in tons

m = number of trips possible in a working day

w = wage rate per minute (hourly wage rate/60 minutes)

a = loading time parameter (minutes/ton)

b = unloading time parameter (minutes/ton)

q_i = travel time parameter (minutes/mile)

x signifies undivided road (30 mph); $q_x = 2.00$

y signifies divided road (45 mph); $q_y = 1.33$

z signifies multilane highway (55 mph); $q_z = 1.09$

θ = variable costs per mile (fuel, tires, oil, etc.)

d = miles traveled

I = idle time where ($60 \leqq i \leqq 120$ minutes)

m is calculated from:

$$m = \frac{8(60 \text{ minutes}) - I}{(q_i d + a + b)}$$

APPENDIX C.

TABLE 1. Annual Depreciation and Operating Costs for a 2,200 Ton Barge.

		Dollars
Barge construction cost[a] (including self-unloading system)		1,000,000
Annual equivalent cost (20 year expected lifetime)[b]	117,500	
Barge maintenance and repair[c]	20,000	
Hull Insurance[c]	15,000	
Total annual cost	152,500	

a Mr. Hector Marchini, Morania Oil Tanker Corporation, New York, New York, telephone interview, November, 1976.

b Because of limited alternative uses, a zero scrap value was assumed.

c Mr. Emmett Butler, Wyllys Barge Lines, Paulsboro, New Jersey, telephone interview, March, 1977.

APPENDIX C.

TABLE 2. Annual Fixed Plant and Site Costs for a 150,000 Bushel Transhipment Facility for Norwich and Burlington.

Cost Item	Years for depreciation	Installed cost	Annual equivalent cost
	-----	(Dollars)	-----
Gravity pit[a]	30	20,000	2,122
Conveyor[b]	10	30,000	4,881
Scale[b]	20	20,000	2,350
Elevators[b]	10	30,000	4,881
Spouts, turnheads[a]	10	50,000	8,135
Silos[a]	40	187,500	19,181
Electrical, heat detection and aeration equipment[c]	10	40,000	6,508
Roadway[c]	40	100,000	10,230
Truck scale[d]	20	60,000	7,050
Office[d]	20	25,000	2,938
Total installed cost		562,000	
Total annual equivalent cost			68,276
Taxes and insurance (3.6%)[d]			20,250
Port Site Cost			15,850
Total Annual Fixed Costs			104,376

a Mr. Thomas Smith, Hough Brothers, Inc., Sunfield, Michigan, telephone interview, September, 1976.

b Estimated from figures provided by Mr. James Bleke, LaGardeur International, Belchase, Texas, and Mr. Thomas Smith, Hough Brothers, Inc., Sunfield, Michigan.

c Mr. William J. Hanekamp, "A Report on the Impact of Unit Train Service for Corn to New England" (unpublished research, Department of Agricultural Economics and Rural Sociology, University of Connecticut), Appendix B.

d Mr. William J. Hanekamp, **op. cit.**

APPENDIX C.

TABLE 3. Labor Costs for a Transhipment Facility Handling 74,000 and 166,000 Tons Annually.

	Number Employees Required		Annual Cost (Dollars)	
	74,000 tons	166,000 tons	74,000 tons	166,000 tons
Administration				
Clerk and Secretary	1	1	6,240	6,240
Accountant	.125	.25	2,000	4,000
Ass't Manager	—	1	—	15,000
General Manager	1	1	20,000	20,000
Total Cost			28,240	45,240
Cost Per Ton (cents)			.38	.27
Direct Labor				
Receiving	.5	.5	5,200	5,200
Shipping	.5	1	5,200	10,400
Scale Weighman	.5	.5	5,200	5,200
General Labor	.5	.5	5,200	5,200
Foreman	1	1	15,000	15,000
Total Cost			35,800	41,000
Cost Per Ton (cents)			.48	.25