Agricultural Transportation Challenges of the 21st Century

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Inland Waterborne Transportation – An Industry Under Siege

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The Problem

America's agricultural producers have always been dependent upon transportation. It is transportation that links the fields of the producer to the tables of the domestic and foreign consumers. Waterborne transportation is one component of the entire transportation system that provides service to a broad group of commodities/products. Farm commodities and farm inputs are extensive users of waterborne transportation.

In a reciprocal way, the waterborne transportation industry depends upon agricultural and other resource movements for their economic livelihood. Grains are particularly dependent upon waterway services, as they access international markets, markets that take over 50 percent of the U.S. wheat production and an average of 22 percent of the coarse grain output. Producers of corn, soybeans, and white and soft wheats are particularly dependent upon foreign consumers and barge transportation.

Because much of U.S. agricultural production is at interior locations far from domestic markets and ports that link our economy to the world, transportation is critical to the competitiveness of the U.S. economy. By investing in an extensive inland waterway system, the United States has been able to improve its competitiveness in international markets. These investments have facilitated lower input costs for U.S. agriculture, provided greater access to international agricultural markets, and strengthened agricultural commodity prices.

The U.S. Army Corps of Engineers (Corps) reports that 10,867 miles of the fuel-taxed inland waterway, with its 171 lock sites and 214 lock chambers, provide indirect employment for 800,000 people in selected user industries located in waterside counties. In addition, the waterways are responsible for about 70,000 direct jobs with a total payroll of $1.7 billion in river States and $428 million in payroll taxes (Federal and State). Moreover, the water transportation industry accounts for savings of $5.5 billion in transportation costs (relative to alternative modes) to agricultural and others shippers.

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U.S. Inland Waterways

Source: Prepared by Tennessee Valley Authority Navigation Group

An identified value of the inland waterways is their ability to efficiently move large volumes of bulk commodities long distances. Just as in the hydroelectric industry, where it is said that the lowest cost source of power is "falling water," "flowing water" can be the source of lowest cost of transportation. Typical tows on the Upper Mississippi River move about 22,500 tons as a single unit, equivalent to about 225 railcars or 870 tractor-trailer units. On the Columbia-Snake River system, where the draft is 12 feet instead of 9 feet but the topography is steeper, a single tow of three barges moves about 10,000 tons, equivalent to 100 railcars or a little less than 400 trucks. If traffic on the inland river system were diverted to another mode, it would take about 6.3 million additional railcar trips or 25.2 million truck trips. Thus, the inland waterways are a critical component of the overall transportation system.

A unique characteristic of the inland waterway system is the combination of public investment and ownership with private use, with sometimes conflicting incentives and outcomes as a result. Shippers/towboat owners want any constraints on lock capacity to be removed at public expense, while government prefers industry to employ self-help measures to solve capacity problems. User fees, a typical response to such problems, are not currently used by the Corps since Congress has generally opposed such means for bringing public and private costs closer together. Such a legislative structure forces the Corps into making assessments of proper investments (or even disinvestments in the Columbia-Snake study[2]) and the timing of the investments. Questions of subsidy, congestion pricing, and any demand side overuse of the waterways are not part of the assigned task. Rather, the attitude of Congress has been to continually make waterway improvements because the value of the inland waterways to the American public is thought to be large.

Even though the historical position of Congress has been to encourage continual improvements in the navigable waterway system, changing societal values and changes in the environment surrounding inland navigation have placed increased scrutiny on those making decisions regarding the provision of navigation facilities. In addition to the traditional considerations of private user costs and public investment costs in locks, dams, and maintenance, the full social costs of waterway transportation are now being considered and publicly debated.

Waterway transportation and the associated improvements needed to make a waterway navigable can create negative externalities such as: (1) reductions in recreational value, (2) reduced scenic beauty, (3) reduced wildlife habitat, (4) increased turbidity of water, (5) reduced commercial fishing, (6) flood impacts, and (7) endangered or threatened species. On the other hand, waterway transportation may reduce negative externalities by taking traffic from more heavily polluting, less safe modes of transportation. Current studies and policy debates take account of these and other considerations such as the impact navigation may have on competing water uses, e.g., the opportunity cost of water moving through a lock rather than through a hydroturbine providing electricity to the region.

This chapter looks at the environment surrounding inland navigation as a dedicated use of the river. One preliminary way to measure the perceived importance of this mode of transportation and any new constraints on it is to examine its treatment in classic transportation or logistics texts. In the early textbooks, pipeline and waterway transportation were usually combined in one chapter, receiving little attention and less analysis. The recent spate of transportation and transportation economics books, text and reference, spend a great deal of effort in characterizing and analyzing the costs, industry structure, and economic performance of the inland waterway system, reflecting the increased study of the mode by students of economics and agricultural production and trade.

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[2]U.S. Army Corps of Engineers, *Draft-Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement-Appendix I*: *Economics*, December 1999.

The first section of this report contains a brief history of the development of and role played by the inland waterway transportation system. The role of this mode in international trade is examined, along with the competitive and complementary roles in a multimodal transportation system. The second section examines the funding of maintenance and investments in the system. The third section looks in greater detail at the waterway system in the context of the Nation's entire transportation system. Commodities carried and modal splits of traffic are examined to explain past performance and future needs. Issues affecting the priority given to navigation as a use of the river are examined in some detail in the fourth section, emphasizing the issues affecting "perspective" toward and "practices" in the river use. The fifth section examines the issue of navigation improvements on the Upper Mississippi River-Illinois Waterway and the potential breaching of dams, with associated loss of navigation, on the Snake River section of the Columbia-Snake River system in the Pacific Northwest. Findings, critiques, and Corps approaches are evaluated in some detail.

The last two sections examine the impact on agriculture resulting from decreasing the priority of navigation in the use of the Nation's inland river systems, looking again at the typical studies on the Upper Mississippi-Illinois River enhancements and the Columbia-Snake operations. The chapter concludes by discussing alternatives for agriculture in its attempts to address some of the coming changes in a proactive manner.

History

The development of the United States is easily traceable to the development of its internal transportation system. The early paths and trails of the pioneers quickly gave way to connecting roads between villages and farms and East Coast settlements, but it was the early navigable waterways that allowed the Nation's productive capability to be realized. The early Erie Canal serves as a model of access to markets and flow of commerce. The romantic Mississippi River of Mark Twain and the romanticized stories of Mike Fink exist in a cultural and historical sense.

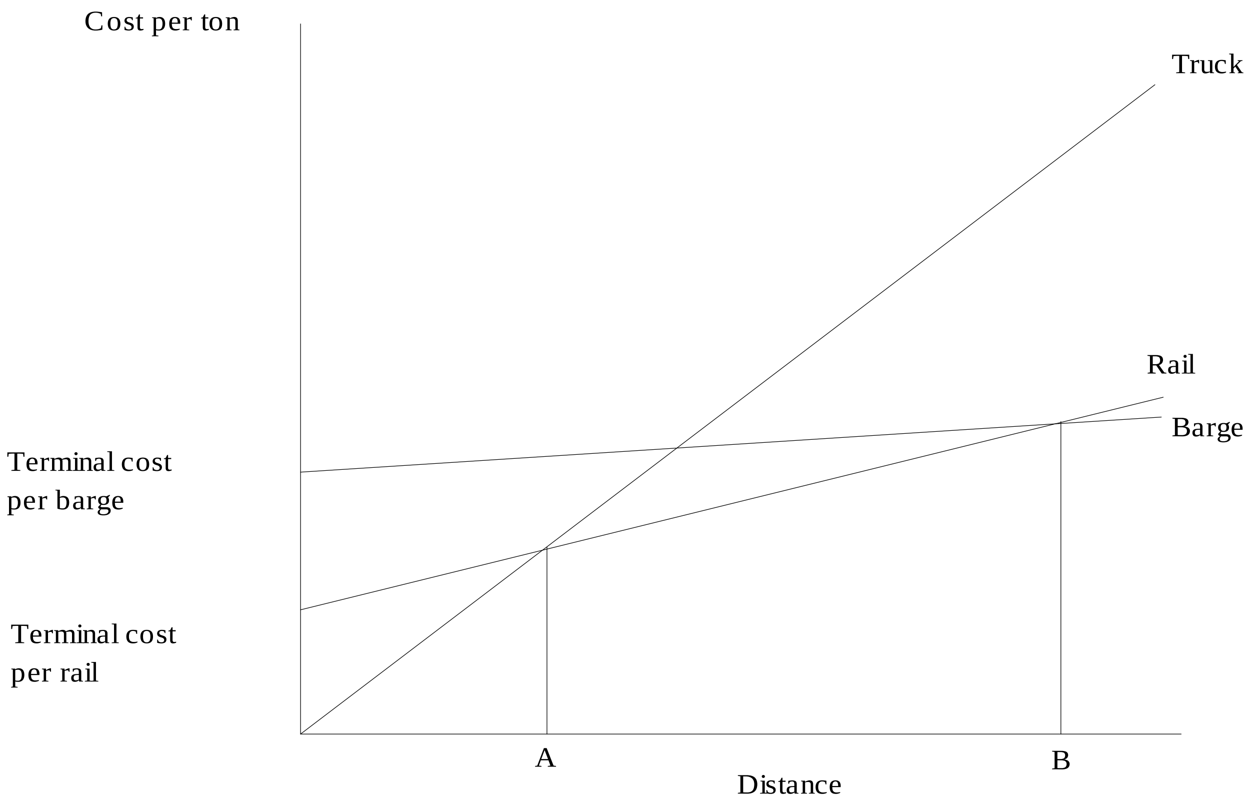
But, in that economic sense, the development of inland navigation by the Federal and State Governments promoted accumulations of capital, rather than a subsistence existence. This capital was then invested in more productive land development with the associated economies of specialization. These economies, not available in a subsistence economy, spawned growth of international commerce, trade, and new profitable markets.

Waterways were developed prior to the advent of the major railways. The initial railroads often served as feeders to the waterways, just as motor carriers later developed as feeders to the railroad. It is often said that the transcontinental railroads are the tie that made the United States one nation. It can also be said that the combination of naturally flowing water and Government enterprise in the inland waterway system combined to develop the capital and understanding of the benefits of long-distance, efficient transportation so that the investments in the rail system would occur.

The benefits of low-cost water transportation caused the Federal Government to foster its growth. Since the early 1800's, the Corps has been charged with establishing and maintaining a system of navigable rivers by improving river passage, increasing flood control, and guaranteeing minimum depths and widths. On the Upper Mississippi River, there are now 29 dams with 35 lock chambers; on the Illinois Waterway, there are eight locks; and on the Columbia-Snake River, there are eight locks and eight dams, which were principally developed for hydroelectric purposes. The projects on the Upper Mississippi River and Illinois Waterway were started in 1930 and completed in 1963. The dams and locks on the Columbia-Snake were initiated in the early 1900's, and the last dam, Lower Granite, was completed in 1975. As these systems have matured, they have become major conduits for agricultural exports to international markets. For example, on the Columbia-Snake River system agricultural products represent the largest component of the tonnage moved on the waterway. In a typical year, farm products account for almost 40 percent of total commodity tonnage transported on the Columbia-Snake River system, going up to 48 percent in some years. Wheat comprises 90 percent of the agricultural products supplied on the river. Timber products account for another 15-22 percent. On the Upper Mississippi River, farm products are even more important, averaging between 53 and 55 percent of the total tonnage. Corn and soybeans are the two largest agricultural commodities moved on the Upper Mississippi-Illinois River systems.

It should be noted that the inland waterway system performs a dual role in the overall transportation system. It serves as a complement to other forms of transportation and as a valuable competitor to keep other modes in check. It is a natural complement to some modes. No grain is grown on the river. It must be moved to loading stations by truck or even, in some cases, by rail. This allows the modes to specialize in the movement that they do best. Trucks do the short haul assembly, with their low fixed costs and flexibility, and the railroads and water transport use their comparative advantage in very low-cost, bulky, long-distance movements. (See figure 1.) In addition to water's complementary role in the transportation system, it serves as a competitor for traffic to the railroads. This competition acts to limit rail rates. These "water-compelled" rates on the railway movements are a natural outcome of strong competition, enough so that in eastern Washington's Whitman County, as late as 1997, grain was being moved at roughly 1936 rail rates. This wasn't because of the benevolence of the Burlington Northern Santa Fe Railway (BNSF) or completely due to technological advances. It was due to the competition from the barge mode operating as far inland as Lewiston, ID.

Figure 1. Typical truck, rail, and barge cost relationships



At distances less than A, truck has a cost advantage. Between A and B, rail has a cost advantage. Beyond B, barge has a cost advantage.

The competition between modes and continuing strong environmental concerns on impacts of waterway facilities improvements caused the funding of navigation improvements to become controversial. One reason was the increased user fees being paid by highway and airport users while comparatively small fees were being paid by the waterways. The push for improvements at the Melvin Price Locks and Dam (replaced Locks and Dam 26) resulted in the Inland Waterways Revenue Act of 1978, which addressed some of those concerns. This act established the Inland Waterway Trust Fund (IWTF), where the tax on fuel used by commercial vessels in inland navigation is entrusted for waterway improvements. The initial barge fuel tax was mandated in 1981 to begin at 4 cents per gallon and, by 1994, level off at 20 cents per gallon. The tax is levied on about 11,000 miles of the most heavily used segments, referred to as the "fuel-taxed inland waterway system" (table 1). The IWTF finances half of new construction and major rehabilitation of the inland waterways infrastructure.

Table 1. Fuel tax applications

If fuel use occurs:	The tax per gallon is:
After September 30, 1980	4 cents
After September 30, 1981	6 cents
After September 30, 1983	8 cents
After September 30, 1985	10 cents
During 1990	11 cents
During 1991	13 cents
During 1992	15 cents
During 1993	17 cents
During 1994	19 cents
After 1994	20 cents

Source: U.S. Army Corps of Engineers, *Inland Waterways Trust Fund Analysis*, IWR, April 2000.

The IWTF is an invested fund; thus, tax revenues are augmented by interest earnings. The U.S. Department of Treasury is responsible for estimating and investing tax receipts, and the Corps is responsible for determining the timing and amount of IWTF expenditures and submitting the annual budget to the Office of Management and Budget (OMB) and Congress. No monies can be transferred out of the IWTF unless there is a law authorizing their expenditure.

The IWTF, physically established in February 1981, started with the transfer of approximately $10 million in fuel tax revenues. The first expenditures from the IWTF occurred in January 1987 for projects authorized by the Water Resources Development Act of 1986. The ending balance for Fiscal Year 1999 was $369.2 million. Table 2 shows the IWTF balances over time.

Table 2. Inland Water Trust Fund balances, 1981-98

Fiscal year	Tax revenue	Interest earned	Expenditures	Ending balance
		millions		
1981	$20.40	$0.08	$0.00	$21.20
1982	$29.90	$5.40	$0.00	$56.60
1983	$28.80	$6.70	$0.00	$92.10
1984	$38.50	$7.70	$0.00	$138.30
1985	$38.60	$24.80	$0.00	$201.60
1986	$42.10	$16.50	$0.00	$260.20
1987	$48.30	$16.50	$24.50	$300.60
1988	$48.10	$24.30	$62.10	$310.80
1989	$47.00	$26.00	$62.80	$321.10
1990	$62.80	$26.20	$117.30	$292.80
1991	$60.50	$21.20	$148.60	$225.90
1992	$69.90	$13.70	$122.70	$186.70
1993	$78.60	$7.50	$74.50	$198.30
1994	$88.40	$9.30	$75.70	$220.20
1995	$103.40	$13.30	$94.80	$242.10
1996	$108.40	$15.60	$85.50	$280.60
1997	$96.40	$17.00	$89.50	$304.50
1998	$89.70	$19.00	$75.00	$342.80
1999	$104.40	$16.00	$120.40	$369.20

Source: U.S. Army Corps of Engineers, *Inland Waterways Trust Fund Analysis,* Inland Waterways Users Board, July 27, 2000.

Water Transportation in the Total Transportation System

The demand for transportation measures the willingness to pay for transportation services, and it identifies how that willingness changes as the price of transportation changes. Transportation demand is the classic "derived" demand, resulting from the demand for a product at a location other than its source, and does not exist separately from the demand and supply conditions for the commodity being shipped. While derived demand forms the basis for transportation demand analysis, it doesn't help much in evaluating real-world problems such as the demand for navigation on particular river segments unless a detailed analysis of the supply and demand for different products at different locations is performed.

When a second mode is introduced into a system, it is possible to analyze the factors that influenced the substitutability of one mode for another. In this way, we get a glimpse of how competitive the different modes of transportation are. This measure of substitutability between services of different modes is the cross-price elasticity of demand. It measures the percentage change in use of one mode given a percentage change in the price charged by the other mode. This concept serves as a good approximation of competitiveness among modes and has a direct impact on the slope of the demand curve (sensitivity of the willingness to pay) for barge transportation.

Because of the differing cost structures of the various modes and the accompanying pricing strategies, various modes behave differently. Rail, with its heavy-fixed cost component on any one movement, is not competitive with trucks on short distance hauls. Barge transportation, with its "way" provided by Federal funding and the recovery of that investment through fuel taxes, is variable cost oriented in its pricing. Its rates are quite volatile and, until recent years of railcar supply programs, have been very responsive to changing market conditions.

The outcome of this competitive search for traffic, especially in the movement of agricultural commodities, particularly grain, varies over time. The large amount of grain arriving at Pacific Northwest terminals suggests the cost-competitive position of barge transportation (tables 3 and 4). Early in the 1980's, new rate structures were introduced by the railroads, as they took advantage of their regulatory freedom and the unit train technology. This allowed a resurgence in railroad market share. In the early 1990's, a similar increase in rail share occurred as volume increased, particularly from Midwest origins. Regardless, barge shipments have also shown a dramatic increase from the 1993-94 crop year, usually in volume but always in market share.

Although data are scarce on the national level on modal divisions, a study by the U.S. Department of Agriculture (USDA) reveals the relative importance up to 1995, by commodity and export or domestic movement (tables 5 and 6). It is evident that barge movements are predominantly part of the export market, with barges usually accounting, across commodities, for 4 percent of the domestic movements and about 50 percent of the export movement. Soybeans utilize barge for about 68 percent, wheat about 58 percent, and corn about 65 percent of export movements.

When ton-miles are considered, the dependence of modes on various commodities is evident. Water transportation relies on field crops (almost 80 percent) and fertilizers/pesticides (16 percent) for their traffic. So, there is a circular dependence relationship; barge firms are heavily dependent upon agricultural inputs and outputs for revenue traffic, and these same products are also dependent upon the water mode.

Table 3. Receipts of grain transported by mode, in bushels, 1980-81 to 1998-99, Columbia River terminals, 1,000 bushels

Crop year	**Rail**	**Barge**	**Truck**	**Total**
1980-81	247,686	217,687	28,024	493,397
1981-82	227,475	205,089	28,681	461,245
1982-83	203,748	170,254	26,054	400,056
1983-84	229,029	171,542	17,234	417,985
1984-85	215,575	169,235	20,123	404,933
1985-86	178,411	116,722	15,819	310,952
1986-87	233,612	140,075	15,720	389,407
1987-88	274,825	199,855	17,032	491,712
1988-89	247,441	198,185	14,707	460,333
1989-90	226,714	165,197	11,798	403,709
1990-91	254,514	179,528	10,505	444,547
1991-92	251,942	162,067	8,406	422,415
1992-93	267,143	155,888	10,456	433,487
1993-94	317,299	185,589	9,353	512,241
1994-95	315,989	176,540	9,282	501,811
1995-96	343,136	227,163	7,564	577,863
1996-97	258,778	203,353	8,055	470,186
1997-98	243,499	196,252	5,995	445,746
1998-99	228,684	232,478	3,477	464,639

Source: Casavant, Kenneth and Terrance Farrell, *Grain Receipts at Columbia River Grain Terminals: 1980-81 to 1998-99*, EWITS Working Paper #12.

Table 4. Percent of grain transported by mode, 1980-81 to 1998-99, Columbia River terminals, 1,000 bushels

Crop year	Rail	Barge	Truck
1980-81	50.2	44.1	5.7
1981-82	49.3	44.5	6.2
1982-83	50.9	42.6	6.5
1983-84	54.9	41.1	4.0
1984-85	53.2	41.8	5.0
1985-86	57.4	37.5	5.1
1986-87	60.0	36.0	4.0
1987-88	55.9	40.6	3.5
1988-89	53.8	43.0	3.2
1989-90	56.2	40.9	2.9
1990-91	57.2	40.4	2.4
1991-92	59.6	38.4	2.0
1992-93	61.6	36.0	2.4
1993-94	61.9	36.0	2.4
1994-95	62.9	35.2	1.9
1995-96	59.4	39.3	1.3
1996-97	55.0	43.3	1.7
1997-98	54.7	44.0	1.3
1998-99	49.2	50.0	0.8

Source: Casavant, Kenneth and Terrance Farrell, *Grain Receipts at Columbia River Grain Terminals: 1980-81 to 1998-99*, EWITS Working Paper #12.

Table 5. Percent modal shares for all U.S. grains and wheat, 1978-95

Year	All grains						Wheat					
	Export			Domestic			Export			Domestic		
	Rail	Barge	Truck	Rail	Barge	Truck	Rail	Barge	Truck	Rail	Barge	Truck
1984	44	46	10	42	4	54	61	30	9	64	6	31
1985	39	50	10	37	4	59	60	30	11	65	6	29
1986	40	52	8	42	4	54	59	30	11	72	4	24
1987	42	51	7	43	3	54	64	27	9	70	3	27
1988	45	47	8	43	2	55	64	29	7	84	3	13
1989	40	48	12	49	3	48	52	36	12	79	3	19
1990	47	47	5	38	5	58	58	41	1	59	3	38
1991	48	48	5	32	3	65	56	36	9	56	4	40
1992	47	47	6	35	4	61	51	36	13	82	4	14
1993	36	51	13	39	3	58	56	26	18	80	3	17
1994	26	55	19	42	3	55	44	36	20	65	2	34
1995	38	51	11	41	3	57	58	32	11	77	3	20

Source: United States Department of Agriculture, *Transportation of U.S. Grain: A Modal Share Analysis*, 1978-95, Washington, DC, 1997.

Table 6. Percent Modal shares for corn and soybeans

Year	Corn						Soybeans					
	Export			Domestic			Export			Domestic		
	Rail	Barge	Truck	Rail	Barge	Truck	Rail	Barge	Truck	Rail	Barge	Truck
1984	41	53	7	41	4	55	19	66	15	22	4	74
1985	38	55	8	31	3	67	16	72	12	21	5	75
1986	35	61	5	36	3	61	24	69	7	30	5	65
1987	32	63	5	40	2	58	22	71	7	31	4	65
1988	36	58	5	37	2	61	23	66	11	32	2	66
1989	35	55	11	51	2	48	21	69	10	25	4	71
1990	32	62	6	43	4	53	19	74	7	28	9	63
1991	28	69	4	37	2	61	21	78	2	28	5	67
1992	24	73	4	39	3	58	23	76	1	28	4	68
1993	24	70	7	35	3	62	22	73	6	23	6	71
1994	18	73	9	39	3	59	14	59	27	31	6	63
1995	33	58	8	38	2	60	23	66	12	25	5	70

Source: United States Department of Agriculture, *Transportation of U.S. Grain: A Modal Share Analysis*, 1978-95, Washington, DC, 1997.

The role performed by these navigable river segments is both one of assembly and distribution, particularly on the Columbia-Snake segment. Upriver movements in the system distribute inputs to agricultural and other producers, over 80 percent of which are fuel products, while another 12 percent are fertilizer. Downriver tonnage is four to five times that of upriver. Grains, mostly wheat, account for over 70 percent of the downriver movements, while forest products account for 7 percent. Upriver movements of commodities, especially agricultural inputs, follow the planting cycles, while downriver navigation shipments move throughout the year, with a peak in August and then again from November to February. There is no indication that capacity has been reached, especially since the enlarging of the Bonneville Lock.

Recent data for movements on the Mississippi River also indicate a similar dependence upon farm products for traffic. Corps data indicate that corn (38 percent), wheat (1.6 percent), soybeans (13 percent), and prepared animal feed (7 percent) constitute 60 percent of total movements on the Mississippi River. Movements in both directions on the river are constrained by winter conditions, with some early peaks in fertilizer and chemical traffic being witnessed when ice breakup occurs.

The projected increases in the volume of traffic on the Mississippi River over the next 50 years are uncertain, still being analyzed and under debate (discussed later). The Corps has predicted an annual growth rate for U.S. corn exports of 2 percent between 1999 and 2051. USDA's long-run baseline projections for the agricultural sector through 2009 show annual increases in corn exports, not necessarily barge movements, of 2.6 percent per year. The ProExporter Network, a forecasting firm located in Olathe, KS, forecasts similar growth, 2.4 percent. Actual recent export levels have caused some analysts to temper these projections so estimates will continue to be scrutinized as more information becomes available.

Future Issues Affecting Navigation Availability

The previous discussion has identified the special importance of water transportation to agriculture and the strong interdependence between the two industries. In this section, current and future issues affecting the supply of and demand for inland water transportation of agricultural commodities is addressed. Many of these issues, while still evolving, can be couched in terms of "perspective" and "practice."

In the policy arena, it is often society's and the Government's "perspective" toward a transportation mode that affects value placed on making investments that enhance the quality, quantity, and cost of transportation service being provided. "Perspectives" affecting provision of water transportation include the volume and need for international trade, the mantra of "feeding the world," concerns about energy consumption and emissions, safety, and the increasing attention paid to overarching environmental concerns such as habitat degradation or loss of an endangered species.

Changing "practices" refer to shifts in the economic environment within which inland navigation operates. Practices that in the future might affect the supply of transportation services range from degradation of facilities (ports, docks, locks, etc.) supporting waterborne movements to financial responsibility of providing the services and facilities. Issues affecting the demand for such services include structural and biotechnological shifts, long-run and short-run capacity concerns of railroads and waterways, short line railroad performance, and international competition. In the following paragraphs, these issues are introduced with some inferences drawn as to their impact on waterway transportation.

Policy Perspectives

Historically, the priority given to providing inland waterway navigation has been based on the value added to the economy. The availability of trade channels and international exports to U.S. agriculture is becoming more critical as U.S. production increases and international competition intensifies. The importance of international trade to American agricultural producers is well documented. The export market accounted for 25-30 percent of total agricultural sales during the 1980's and 1990's. Over this period, U.S. wheat producers exported an average of 51 percent of their annual production; U.S. coarse grain producers exported an average of 22 percent of their annual production and accounted for nearly 60 percent of world trade in coarse grains. Indeed, policy makers seem to have the perspective that international trade and foreign markets will continue to be a necessary complement to the domestic demand for U.S. agricultural producers. Increasingly, it is realized that the impact of increased (or sustained) trade, while direct, is multilayered. It increases the price and quantity of traded goods in the exporting region, encourages larger scale and more efficient production methods, entices investments into new production techniques, and even allows new or different combinations of inputs to be used as the producer searches to maximize profits and take advantage of these trade opportunities.

Another policy perspective is that the United States has both an ability and an obligation to feed the world, or at least stand ready as a supplier of last resort. In times of famine or crop failures, donor institutions have successfully helped abate these crises with U.S. grains and food products, thus “feeding and nourishing a growing world population and helping farmers grow a wide variety of goods to feed a growing world." This perspective appears to be part of the current policy approach. However, some recent evaluations suggest a different perspective may be evolving. In examining the issue of grain exports from the Upper Mississippi River Basin, the Institute for Agriculture and Trade Policy observes that for every ton of corn exported to "poor countries" in 1996, 260 tons were exported to a wealthy Organization for Economic Cooperation and Development country. No soybeans were exported to poor countries in 1996, while 17.8 million metric tons went to wealthy countries.

This, however, should not be surprising because effective demand depends on willingness and ability to buy. Thus, market incentives move exports to areas where economic ability to pay accompanies the desire for the grain. Examining this perspective on why navigation facilities should be made available shouldn't stop at the above impacts but should consider what the world price (which the poor countries have to pay in some fashion) would be if the U.S. exports were to be taken off the international market.

Energy and Emissions

Conventional wisdom holds that barge transportation is fuel-efficient and environmentally advantageous. Recent Corps pamphlets suggest, on average, a gallon of fuel allows 1 ton of cargo to be shipped 59 miles by truck, 202 miles by rail, and 514 miles by barge. The source of these estimates is not known (although Eastman's work is often cited[3]), suggesting that the relative coefficients may be 20 years old. Table 7 indicates more recent energy coefficient estimates based on British Thermal Units (BTU) per ton mile. These data suggest a relative shift so that in recent years, the energy advantage of barge has diminished relative to rail. Additionally, since truck serves as the feeder to both the rail and barge shipping points, the relative distance traveled by truck in each origin-destination movement may be the ultimate determinant of which intermodal combination is most energy-efficient.

Table 7. Summary of energy coefficients found in the literature, BTU's per ton mile

Mode	Casavant and Knighten (1981)	Ross (1989)	Greene (1996)	Davis (1998)
Truck	2,400	3,400	558	549
Rail	750	490	344	368
Barge	500	340	398	412

A recent study[4] into the proposed Columbia-Snake River partial drawdown (four dams on the Snake River) found that energy usage increase slightly if breaching occurs. The study shows increases were about 19 percent for wheat movements and about 37 percent for barley. Much of the increase is due to trucks making longer trips to deliver grain to Columbia River ports at or below Pasco, WA, rather than to Snake River ports.

The Corps also commissioned a study[5] into the impact on energy consumption of the proposed lock improvement projects on the Upper Mississippi River-Illinois Waterway. Tolliver found that significant decreases in fuel consumption are projected for most of the proposed waterway improvement alternatives. To the extent that waterways are more energy-efficient than railroads, the lock improvements would result in a decrease in fuel consumption. No indication was given of the role of trucks in the various movements in the study. Instead, the study found "railroads have become much more fuel-efficient over time, and the relative energy benefits of waterway

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[3]Casavant, Ken and Michael Lee Knighten. *Energy Impacts of Alternative Institutional and Policy Changes on the Pacific Northwest Wheat Transportation*, Department of Agricultural Economics, Washington State University, Pullman, WA, 1981.

[4]Lee, Nancy and Ken Casavant, *Impacts of Snake River Drawdown on Energy and Emissions*, EWITS Report #26, Washington State University, 1999.

[5]Tolliver, Denver, *Analysis of the Energy, Emission and Safety Impacts of Alternative Improvements to the Upper Mississippi River and Illinois Waterway System:* Draft Report to the U.S. Army Corps of Engineers, March 2000.

transportation have become smaller."

What is evident, from a policy perspective, is that the relative energy coefficients of the various modes are imprecise and require definitive information on modes, routes, cargo, roadways, and climatic conditions for the individual movements under investigation. The uncertainty of energy consumption at a time when energy concerns are increasing in intensity may affect the perspectives of policy makers toward inland navigation.

These two studies (Lee, Tolliver) also examined emissions output under the proposed improvement projects. Tolliver found that fuel-efficiency advantages translated into lower emissions for traffic kept on the inland waterways as a result of the proposed projects. A third study by Lee and Casavant on the Columbia-Snake River drawdown issue found the loss of barge transportation on the lower Snake River would increase emissions by 1.39 percent. Oxides of nitrogen, hydrocarbons, and carbon monoxide components increased by 3.4, 2.5, and 2.5 percent, respectively. Particulate matter increased far more, up to 10 percent. On the other hand, sulfur oxide emissions decreased by 21 percent. Barge emissions decreased 39 percent, and rail and truck emissions increased by 94 percent and 16 percent, respectively, due to the new transportation moves.

Both of these studies of emissions based their analysis on the amount of fuel consumed; thus, they have the same needs for specific, related analysis as do the energy coefficients.

Other environmental concerns

The public perspective toward the environment is now, more than ever, a policy issue of importance. As is discussed later in this section, the Corps is charged with the environmental protection of resources in the waterway while it simultaneously seeks to maximize the economic benefits of the waterway. The National Environmental Protection Act and the Endangered Species Act reflect that current priority ranking of societal values. These issues do portend, under current application, a decreasing priority for navigation when making public investments in river infrastructure.

Market Practices

Port Development. The majority of U.S. exported agricultural commodities and products move as waterborne commerce through the Nation's ports (tables 5 and 6). Exports are often transported through particular ports because of their proximity to that port, availability of low-cost transportation to that port, and accessibility to specific foreign destinations. For example, approximately 70 percent of bulk export grain is moved through U.S. Gulf ports after being barged down the Mississippi River from Corn Belt production areas. Some of this grain is subsequently moved through the Panama Canal.

When the transportation system is constrained, potential trade benefits are compromised. Current constraints on ports include the use of larger ships and inland modal congestion. Larger ships are being used in the maritime movement. These ships then put pressure on port services by requiring deeper drafts with accompanying dredging and more storage and unloading/loading capacity. The need for increased and continuous dredging is counterbalanced by environmental concerns and required environmental reviews. Inland modal congestion unfavorably affects port efficiencies and ship utilization, thereby increasing costs when accessing the international market. (For example, trucks haul cherries produced in Washington State to ports, but two-thirds of the travel time occurs on congested highways within 50 miles of the port.) Continued port constraints could lower grain prices and make domestic markets increasingly attractive, such as rail to the Pacific Northwest for interior-produced grains.

Cost Recovery Distribution for Waterways. The locks and dams on much of the inland waterway system are undergoing serious deterioration. The average ages of the locks on the Mississippi and Illinois Rivers are 55 and 60 years, respectively. Several of these locks have reached their design capacity because larger 15-barge tows, requiring 1,200 feet to traverse a lock in one pass, have become common. Only three of these locks currently handle 1,200-foots tows; thus, expensive, inefficient, congestion-increasing double lockage occurs. Current studies indicate a price tag of over $1 billion to carry out desired improvements. The IWTF is forecast to have revenue to cover its half of that expenditure as mandated by statute. To pay for the other half, various proposals have surfaced to pay for rehabilitation, new construction, and even the operating and maintenance costs ($433 million for all fuel-taxed waterways). Questions revolve around who should pay for improvements, which areas (river segments) should receive investment funds, and what value is placed on efficient waterways by the Federal Government. Does the Federal Government value waterways enough to continue to pay operations and maintenance costs? How much of the bill should taxpayers fund in addition to users? The answers to these policy questions will affect the practices on the river and the performance, competitiveness, and supply of services on the entire inland waterway system.

NAFTA Issues. The impact of the North American Free Trade Agreement (NAFTA) is still being felt and analyzed in U.S. commodity and transportation markets. A classic example of the potential benefits of free trade is that total agricultural trade from the United States to Canada and Mexico has increased by over 50 percent in the 7 years since its initiation. The ability of the transportation system--all modes and attendant infrastructure needs--to handle that volume and the expected increase in volume has been a source of concern. Four-mile backups in truck traffic at border crossings, rail capacity constraints caused by infrastructure inadequacies, and needed business and regulatory operational improvements have combined to create barriers to trade. In recent years, there have been significant improvements in daily throughput at border locations, but peak movements and perishable products still undergo stress and delay.

Waterborne commerce can be affected in several ways. Attempts to move around congestion points at the border have resulted in attempts to develop barge shipments from the Gulf to Mexico ports that are either barge-rail or barge-truck combinations. While providing traffic in the Gulf area for barge operators, most of these efforts use railcars as the "box" for moving the grain on barge arrangements. This suggests that as trade with Mexico increases, whether moved in some short line haul by barge or not, rail shipments may increase more than truck shipments, thus moving a small amount of traffic to rail. This longer haul to Mexico and the ability of rail to better serve specialized smaller markets will allow more U.S. grain exporters to access the market. Conversely, it is at least possible that Canadian grain could be moving on the Mississippi River as a new outlet to the international market for Canadian producers.

Production Shifts and Shapes

The earlier "practices" were generally supply shifters in the provision of transportation. However, the demand for transportation services on the waterway can be affected by the location and volume of total and commodity-specific production (shifts and shapes), the capacity of the competitive modes, and the extent of international competition facing the commodities being produced and transported.

The notion that agriculture is a static nonchanging industry is simplistic and erroneous. Recent changes in production have altered the breadth and depth of the landscape of production agriculture. Biotechnology (biotech) is revolutionizing production agriculture and simultaneously creating societal and institutional/marketing concerns. These new technology-based varieties have improved yield, decreased costs, and offered increased financial returns to producers. The potential applications of these technological developments is extremely broad. The products coming forth can be and are tailored for specific end uses and markets. Such market specificity suggests a new emerging need for identity-preserved shipments.

The recent transfer of biotech to overseas producers and exporting (participating) nations is growing rapidly as purveyors of biotech seek new markets. This intercountry technological transfer has serious implications for international competition for those U.S. commodities often carried via waterborne commerce. Biotech also serves to make domestic uses and processing more attractive, as it offers specific variety and genetic characteristics useful to these domestic processing outlets. A shift from export markets to local or domestic processing markets may decrease the volume available for movement on the inland waterway system. Additional issues are whether the bulky, undifferentiated movements of the inland waterway system have the ability to handle identity-preserved shipments. If biotech causes production to move closer to the end-use or processing location, more use of truck or rail and less use of waterways may be expected.

Even without biotech causing production shifts, U.S. agriculture is undergoing structural shifts. Since transportation demand is contingent upon commodity demand, transportation is desired where products are produced. Production efficiencies may be significant enough to cause geographical shifts even if transportation costs increase. Historically, the size of farms has increased as the number has declined, leading to larger shippers, larger trucks at the farm, and, therefore, greater marketing flexibility at the production level. Grain production has moved west, especially corn and soybean acreage; poultry and livestock feeding has relocated to the Southern United States and increased overall. A regional feeding activity which is serviced by rail and some truck, hog production has moved away from its historic proximity to local corn production to the Southeast, causing a further need for shipments into these new areas.

As mentioned earlier, domestic grain processing has also undergone significant growth. Corn processing, in particular, has increased from 9 percent of domestic corn utilization in 1976 to over 18 percent in recent years. These corn products are generally moved by rail to ports or consumption points rather by water transport. The just-in-time and off-the-shelf inventory logistic philosophies in handling these products has placed of a premium on time, reliability, and predictability of arrivals, again giving railroads a competitive advantage over water. The observed structural shifts have not stopped, and the ultimate outcome depends on future developments, not past locations.

Railroad Capacity Concerns

A direct influence on the demand for waterborne commerce is the competitive rates and services offered by railroads. A continuing concern is the capacity of railroads to provide service as demanded by agricultural shippers. These capacity concerns occur in both the near term and long term for the Class I railroads and in the question of short line railroad survivability. Agricultural shippers, along with shippers of other bulky, nonperishable commodity products, incur rates whose rate/cost ratio for the railroad is quite low relative to other product movements. Thus, when car capacity shortages occur, bulk commodity shippers are often the first to experience inadequate service. Just as captive shippers realize higher rates because of inelastic demand with respect to price, they also realize poorer service because of a relatively inelastic demand with respect to service.

The overall capacity of the railroad industry has adjusted from a condition of over capacity to one in which seasonal and geographic shortages occur. The Staggers Rail Act of 1980 released the railroads to act as a profit-maximizing entity rather than a recalcitrant public utility. The resulting technology and rate innovations have resulted in high-volume, lower cost (rate) movements for many agricultural commodities. Smaller shippers, with their comparatively small shipments, yield low profits to railroads and are at a disadvantage when arguing for railroad service. However, in some cases, shippers with low revenue/cost ratios often realize the best rail service because of more alternatives (which generated the low rates in the first place).
But, recent broad rail congestion associated with the pains of mergers, new markets, and outdated switching yards/connection lines/ports suggests that even the heavy volume movements may experience long-term problems of capacity availability. Rationing, auctioning, or value pricing of capacity made scarce by operational inefficiencies may occur.

If long-term capacity concerns are a disease of the railroad system, short-term capacity or "car shortages" are the festering wound continually affecting agriculture. Car shortages are the immediate concern of the shipper and an indication of market failure. However, it is not failure for the shipper but a failure of the market to equate the quantity supplied to the expressed demand. Historical inflexible pricing schemes have been the source of market failure. Railroads and shippers have increased the number of cars by over 25 percent during the past 10 years. Almost all new cars are of the 286,000-pound class with large cubic capacity construction which yields another 10-percent increase in available capacity. But agricultural production and movement continue to be seasonal; what is needed are market mechanisms that reflect the value of service to the shipper. The recent freight guarantee programs (BNSF's Certificate of Transportation program, Union Pacific’s Car Supply Voucher Program, Canadian National’s PERX program) are major entries into market driven pricing of rail service.

These three tiers of service indicate a movement toward market-clearing prices, with the tariff cars most commonly in short supply. The guaranteed freight section must have the ability to fill capacity needs, or these rates become essentially paper rates. The long-term problems of congestion and infrastructural inadequacies underlie the success of these efforts. As effective rail rates increase to accommodate or meet seasonal demands, waterborne commerce may experience strong demand as long as short-term railroad capacity issues continue. The full extent of the demand for waterborne commerce will depend on how agricultural shippers can adjust shipping patterns during the year.

A third element of railroad capacity involves the continuing availability of short line railroads. These railroads, by most measures, must be considered a success thus far. Initially serving as an alternative to low-density rail line abandonment, thus far, they have evolved into an efficient gathering or feeder system to the Class I mainline railroads. Interestingly, this is the same role played by trucks in their early development. These short line or regional railroads have been extremely creative and shipper-oriented in finding new markets, developing new services, and lowering costs of operation via modernized work rules. These railroads have developed short haul efficiencies that allow the long haul cost efficiencies of the Class I railroads to be utilized.

However, short line railroads continue to be only marginal in viability. Initially, they were dependent upon the financial agreement made with their Class I originator. Now rate splits are dependent upon Class I needs or desires, and car supply is similarly dependent upon the Class I carrier. New technologies involving 286,000-pound cars or 108-car trains will place extreme pressure on short line railroads, since estimates are that one-third of short line trackage can't currently handle these cars. The initial trackage and infrastructure obtained from the Class I railroads often needed rehabilitation. If or when short line railroads fail and trackage is abandoned, waterborne demand may increase, if those abandoned lines are located within economical truck distance of waterways. The increased costs and road damage from trucks would then need to be balanced against the larger and more efficient trucking from farms discussed above.

International Competition

Just as in the United States, investments in waterborne transportation increase the competitive position of the investor nation in international trade. This competitive position may well be shifting, particularly to China, Brazil, Argentina, Bolivia, and, to a lesser degree, Paraguay.

With access to World Bank financing, China has been upgrading both domestic grain transportation systems and ports for international trade. These improvements have the potential to aid U.S. exports by improving port delivery systems but could also increase competition by making Chinese grains more cost effective in the international market. Further, these improvements could internally facilitate better grain distributions from producing to consuming regions, thus reducing the need for imports or reducing export potential.

Argentina’s public and private sectors have invested heavily in port infrastructure, dredging three or more port areas and investing in inland water transportation systems. Plans are underway to bring in soybeans from Argentina, Bolivia, and Brazil; processing the soybeans near these ports; and then exporting the processed products into the international market. Some soybeans are currently being barged down the Parana River to Rosario, Argentina, where they are crushed.

Both navigable waterways and railroads have received attention and investment in Brazil. Successful privatization of the railroads is expected to lead to new lines and access to new markets. New dams and navigable waterways are expected to open new markets as well as increase the profitability and production of Brazilian agriculture. The net result of these new transportation efficiencies is new production, spurred on by biotech transfer and new, more cost-effective access to international and domestic markets.

Capacity and Priority of Navigation

In this section, two projects potentially critical to transportation of agricultural commodities into international markets are reviewed. Both of these reflect the waterborne industry as being under seige. The Upper Mississippi River-Illinois Waterway System Navigation Study (UMR-IWS)[6] examines the economic feasibility of navigation improvements to that waterway system to reduce delays to commercial navigation traffic. The Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement (FR/EIS)[7] examines alternative means to halt and reverse the decline of listed species of salmon and steelhead.

Both projects, especially in the UMR/IWS, include an examination of the role of navigation in the multiple uses of each river. The fact that this role is being examined reflects changing values and a new philosophy in the United States--don't just do something (build or enlarge or operate a dam) because it can be done. Instead, study and think about the issues. Such a philosophy, if it does reflect the majority of the populace, is a major change in perspective. Now the questions are: "Is the project needed?" "At what total costs is it obtained?" "Can it be done more cheaply or with less environmental impact?" The policy debate is further enhanced by the understanding that having a benefit-to-cost ratio greater than 1 does not necessarily suffice for construction or continued operation. Society then has to consider opportunity costs as public resources are allocated to alternative projects that are all deemed to be feasible. Proponents of environmental considerations warn, quite effectively, that partial analysis can lead a riverine environment to "death by a thousand cuts," none of which is individually fatal, but the body still dies. In the issue of salmon survival and restoration, also death by a thousand cuts, the focused question is, "Are continued dam operations the meat cleaver to the life of the endangered species?"

The Upper Mississippi River-Illinois Waterway System Navigation Study

The focus of this study is capacity, namely, the functional capacity of the UMR-IWS to move agricultural and other commodities to export ports. The study addresses existing and future delays (from double lockage and increased traffic) at lock sites on the river system, examining 37 navigation lock sites and about 1,200 miles of navigable channel. The benefits of navigation improvements accrue from avoided congestion or delay times, and the costs arise from construction and environmental impact (mitigation) costs. It should be noted that Congress in 1986 specifically recognized this system as "a nationally significant ecosystem and a nationally significant commercial navigation system and it should be administered and regulated in

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[6]U.S. Army Corps of Engineers, *Draft-Summary of Large Scale Measures Screening, Interim Report*, October 1999.

[7]U.S. Army Corps of Engineers, *Draft-Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement-Appendix I: Economics*, December, 1999.

recognition of its several purposes."

The major thrust in construction of the Upper Mississippi-Illinois River locks occurred in the 1930's-1940's. Originally designed to service a small percentage of today's traffic and significantly smaller tow sizes than the current 15-barge tow, delays have been steadily increasing, especially since the original 600-foot locks require double locking of the typical tow. Initial reconnaissance reports by the Corps in 1990 and 1991 indicated a benefit-cost ratio of 1.3 to for improvements on the Illinois River and 1.4 to 1 for phased improvements at 14 lock sites on the Upper Mississippi River. However, it should be noted that no explicit consideration of the elasticity of demand was made. Rather, benefits were measured by assuming that all potential waterway tonnage would be willing to pay the transportation cost for the next cheapest mode. In reality, many shippers would not be willing to pay such a high rate. Thus, the benefits of waterway transportation may have been overstated.

The UMR/IWS study commenced in 1993 and was unique in that Corps Headquarters' directive was to include both rivers and all potential locks in a system feasibility study. By 1994, the System Equilibrium Model was being developed. This model departed from previous Corps models by explicitly considering a demand function. The shape of the demand function later became controversial in the public debate about the Corps' initial findings.

The project focused on possible extensions of existing locks, extension of guidewalls, and development of adjacent moorings. Extensions of existing locks were estimated to cost about $95-$125 million per lock, with the benefit of cutting lockage time in half. Guidewall extensions were to cost about $30-$40 million per lock and offered a reduced lockage time of 20-25 percent. Adjacent moorings, buoys, or cells would keep tows away from banks and other environmentally sensitive areas but reduced lockage time 5-15 percent. As engineering costs were developed and then reestimated, the costs of improvements per 1,200-foot lock decreased from $380 million estimated in the reconnaissance reports to a $120 million final estimate. Float-in technology was used to minimize construction activity in the lock area. The final alternative plans receiving indepth analysis were combinations of these three facility improvements: lock extension, guidewall extension, and mooring facilities. Evaluating the river as a system and its related traffic led to grouping of improvements into scenarios or plans. The final four plans receiving most analysis and Corps consideration are shown in table 8 under a plan of either building as soon as possible or optimally timed to maximize the average annual net benefits. It should be restated that these are only preliminary, tentative findings and are subject to revision by the Corps.

Table 8. UMR-IWS benefit and cost summaries (thousands of dollars)

Possible Plans	Average annual navigation benefits		Average annual const. & site specific environ. costs		Average annual environmental costs		Average Annual Costs		Benefit/Cost Ratio	
	*ASAP	**OP timing	ASAP	OP timing	ASAP	OP timing	ASAP	OP timing	ASAP	OP timing
Mooring cells: 12,18,20,22,24 Powered kevel guidewalls 20-25	27,730	31,875	18,252	18,316	5,145	5,145	23,397	23,461	1.19	1.36
Mooring cells: 12,18,20,22,24 Locks 20-25 Powered kevel guidewalls 14-18	72,523	79,349	63,182	63,326	9,579	9,579	72,761	72,905	1.09	1.27
Mooring cells: 12,18,20,22,24 Locks 20-25 Powered kevel guidewalls 14-18 Peoria, LaGrange	78,204	86,712	68,791	65,832	12,025	10,674	80,816	76,506	1.06	1.31
Mooring cells: 12,18,20,22,24 Locks 20-25, Peoria, LaGrange Powered kevel guidewalls 14-18	100,635	98,767	99,305	83,729	13,744	11,713	113,049	95,442	.997	1.25

* - as soon as possible ** - optimum timing

Source: U.S. Army Corps of Engineers, *Draft - Summary of Large Scale Measures Screening, Interim Report*, October 1999.

Based on the Corps assumptions regarding future traffic demand and demand elasticities, it is evident that all plans have benefits-to-costs ratios at or slightly above or below 1, in the case of building as soon as possible (ASAP), and significantly greater than 1 if the construction and operation is optimally timed. Much discussion among the study team and in the press has concentrated on the plan for lock extensions at Dams 20-25 on the Upper Mississippi, the Peoria and LaGrange Locks on the Illinois, powered kevel guidewalls on Dams 14-18, and various mooring cells on selected Upper Mississippi dams.

The study hasn't been without controversy. Considerable attention is now being given to the traffic projections, demand elasticity, small-scale improvements, and environmental concerns. A National Research Council Committee has been assembled, at the request of the Corps, to review the study, examine and evaluate the analytical process, and develop suggestions for improvements in the Corps structure and process for conducting feasibility studies of this nature. Specific attention is to focus on economic assumptions, methods, and forecasts regarding barge transportation demand on the river system. Further, the committee is to comment on the extent to which larger issues of formal U.S. Federal water resource planning guidelines, possible environmental impacts, and the full costs of navigation improvement are being appropriately considered in the navigation system feasibility study.

Specific concern has focused on the traffic projections to the year 2050 because it is this increasing projected level of traffic that leads to a positive benefit-to-cost ratio. The Corps model predicts that export demand for grains will continue to increase, both in the short and long term. For corn, the increase is 2 percent per year. Various critics accuse the Corps of either overestimating or underestimating future traffic, by either ignoring structural shifts in the international market or by ignoring the yield impacts of biotech in competing production regions.

These concerns about the projections and the shape of the demand curve led the Corps to reevaluate the projections and demand curve. This reestimation of projections has been done and is currently under independent review. The critical question of the appropriate shape of the demand function continues to be debated. A crucial parameter in the mathematical expression influencing the demand curve and, therefore, the elasticity of demand is the equation’s coefficient, “ N.” Its value was set at 1.2, with no empirical basis. The Corps’ own economist earlier thought the value of N=2 should be used for grain, again not empirically tested. Such a value would result in lower estimated benefits. A near-term improvement to be considered by the Corps is to conduct (or evaluate if available) several empirical case studies involving several elasticity estimates, an elasticity incorporating alternative transportation modes, differing routes, and alternative markets/end uses. The current representation of alternative modes and routes is quite simplified. Many other issues are being reexamined, but they are comparatively modest in impacts as compared to the investigations of projections and elasticity coefficients.

The Corps approach to addressing and costing out environmental impacts is to "assess, avoid, or mitigate" any perceived environmental impact. Thus, the environmental cost simply becomes the cost of mitigation. The Corps' 57 studies on environmental relationships include substantial information on physical inventories and descriptions and modest information on the biological production functions. Such an approach forces reliance upon mitigation costs, even though the quantitative biological effectiveness of such mitigation strategies is still unknown. Critics of the environmental studies use the above issues as the focus of their arguments. Even as the Corps has made significant advances with its use of a systems approach, consideration of the elasticity of demand, and broad public processes, debate continues.

Columbia-Snake River Dam Operations

Similar to the UMR-IWS, this study is concerned with capacity and use of a public resource in a multiple-purpose setting. However, the Lower Snake River Juvenile Salmon Migration FR/EIS deals with decreasing navigation, irrigation, and hydropower capacity on the river, as contrasted to the attempt to increase capacity on the UMR-IWS. Between 1991 and 1997, due to declines in abundance, the National Marine Fisheries Service (NMFS) made the following listings of Snake River salmon or steelhead under the Endangered Species Act: sockeye salmon (endangered in 1991), spring/summer Chinook salmon (threatened in 1992), fall Chinook salmon (threatened in 1992), and steelhead (threatened in 1997).

NMFS' Biological Opinion on operations of the Federal Columbia River Power System established measures to halt and reverse the decline of these listed species. This led to a study designed to evaluate the feasibility, design, and engineering work for those measures. The specific purpose of the feasibility study was to evaluate and screen structural alternatives that may increase survival of juvenile anadromous fish through the four Snake River dams (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite) and assist in their survey. After preliminary examination of temporary drawdowns to natural river levels, spillway crest, and other improvements, the study analyzed four courses of action: 1) no action, 2) maximum collection and transport of juveniles (without major system improvements such as surface bypass collectors), 3) maximum collection and transport of juveniles (with major improvements such as surface bypass collectors), and 4) dam breaching or permanent drawdown to natural river levels for all reservoirs. The geographic area covered by the FR/EIS was the 140-mile-long lower Snake reach between Lewiston, ID, and the Tri-Cities in Washington. An economic appendix measured the social and economic effects of the proposed alternatives. Results were organized loosely into four accounts as laid out by the Principles and Guidelines of the U.S. Water Resources Council:

1. The National Economic Development (NED) Account, which displays changes in the economic value of the national output of goods and services (concerned with economic efficiency at the national level);
2. The Environmental Quality (EQ) Account, which displays nonmonetary effects on significant natural and cultural resources (incorporating qualitative information);
3. The Regional Economic Development (RED) Account, which addresses changes in the distribution of regional economic activity (examines local impacts in the region) and;
4. The Other Social Effects (OSE) Account, which addresses potential effects from relevant perspectives not reflected in the other accounts (community impacts; life, safety, and health factors; displacement; etc.)

A 100-year period of analysis, unlike the 50-year projections of the UMR/IWS study, was used to assess all project impacts. Effects were discounted and presented with three discount rates: 6.875 percent (the Corps analysis rate), 4.75 percent (Bonneville Power Administration’s customary rate), and 0 percent (the tribes’ perspective, reflecting the value of their cultural future). Use of the alternative rates had little effect on the rankings of the alternates.

The draft results of the Corps analyses are shown in table 9. These results show the net benefit (cost) of each alternative in comparison to alternative 1 (no action). This summary indicates that alternative 4, dam breaching, has significantly higher annual net costs than the other alternatives.

Table 9. Summary-average annual economic effects, 1998 dollars (thousands of dollars)

Costs	**Alternative 2**	**Alternative 3**	**Alternative 4**
Implementation costs	-	(5.931)	(48,787)
Power	-	-	(271,000)
Transportation	-	-	(24,034)
Irrigation/water systems	-	-	(15,424)
Total costs	-	(5,931)	(359,245)
Benefits			
Avoided costs	-	-	29,178
Recreation	2,030	2,080	82,000
Anadromous fish	160	161	1,593
Implementation costs	3,457	-	-
Power	8,500	8,500	-
Total cenefits	14,147	12,982	112,771
Total benefits - costs (net)	**14,147**	**4,810**	**(246,474)**

Notes:
1. These costs and benefits, calculated for a 100-year period of study extending from 2005 to 2104, are discounted using a 6.875-percent discount rate and converted to 1998 dollars.
2. Costs and benefits are presented for alternatives 2 through 4 net of the base case (alternative 1).
3. A positive monetary value indicates that the alternative being evaluated has a lower cost or greater benefit than alternative 1. A negative monetary value indicates that the evaluated alternative has a higher cost or lower benefit than alternative 1. Positive monetary values, therefore, represent benefits, while negative values represent costs.

Source: U.S. Army Corps of Engineers, *Draft-Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement-Appendix I: Economics*, December 1999.

By far, the largest economic cost is associated with the lost power ($271 million) from breaching the dams. Implementation costs are second in magnitude, and transportation is third, still only about 9 percent of the power costs and 7 percent of total costs. Moreover, its costs far outweigh its benefits. Alternatives 2 and 3 are actually less costly than alternative 1 because water spill is avoided. These alternatives also result in power benefits. Thus, these alternatives show positive net benefits.

Included in the policy debate are the passive use or existence values used to put a financial estimate on the value people place on a healthy river's existence, whether they actually use it or not. Although disagreements on methodology exist, the passive use value was estimated to range from $66 million to $879 million per year. Another major difference in this analysis is the inclusion in a chapter and in numerous sections of tribal "circumstances and perspectives." This approach details tribal impacts from the alternatives in treaty rights fulfillment and cultural restoration and would be included in any EQ Account discussion. (Correspondingly, tribal interests loom large in development of the Parana River in South America.)

The four Lower Snake dams are multipurpose facilities that provide a variety of public benefits. The purposes authorized by Congress for the overall Lower Snake River project are navigation, hydropower, irrigation, recreation, and fish and wildlife. Since these projects are essentially run of the river, with little storage for flood control, they are not able to store enough water to offer flood protection.

The navigation or transportation component of the study, while significantly smaller than hydropower in economic impact, has had substantial political impact in the overall issue of dam breaching. (Irrigation, with only 13 farms being affected, also has a strong political base in the discussion.) The transportation system impacts that would occur under dam breaching were estimated using a transportation system model designed to track and estimate the cost of transporting commodities on the river. The Corps used modal costs computed through analysis of fixed and variable costs of each transportation mode--truck, rail, and barge. Projections of future commodity shipments were developed through analysis of waterborne commerce data for the decades of the 1980's and 1990's (unlike the series used for the UM/IWS). Forecasts of future shipments were developed for each of eight commodity groups. Projections were made at 5-year intervals from 1997 to 2017 for the various commodity groups. Due to the degree of uncertainty inherent in long-range forecasting, the Corps chose to keep projected volumes at the 2017 level beyond that year, in contrast to the UM/IWS study).

Grain shipments, mainly wheat and barley, dominate movements on the river (table 10). Projections indicate an 11-percent increase in grain shipments over the 20-year span, or an average of about half of 1 percent per year, with no increase after that period. Grain shipments with the dam breaching scenario were assumed to move by rail or truck to the nearest barge facility on that portion of the river below Ice Harbor Dam, Pasco, WA. Infrastructure capital costs, in addition to the NED costs, were estimated at $206-$531 million (railroad upgrades, additional rail cars, highway improvements, river elevator capacity, county elevator improvements, and export terminal rail car storage).

A critical capacity assumption in the model was that, with dam breaching, modal, handling, and storage capacity could be expanded on a regional basis to meet geographic shifts in demand without significant increases in long-run marginal and average costs. Similarly, it was assumed that grain elevator throughput capacity could be increased without impacts on costs.

The Independent Economic Analysis Board (IEAB) of the Northwest Power Planning Council was the official reviewer for the economics appendix. After several revisions, the IEAB found that the analysis of the Corps was defendable and had improved but had continuing problems. Some of the analytical concerns (rail capacity, no increasing costs, transportation model structure, and highway impacts) would have increased transportation impacts while others would have decreased the magnitude of the impacts.

Table 10. Waterborne traffic projections above Ice Harbor Lock 2002-2022 (in thousands of tons)[1]

Commodity group	Average	2002	2007	2012	2017	2022
Grain	3,019	3,647	3,799	3,798	3,892	4,052
Wood chips and logs	716	694	694	694	694	694
Petroleum products	118	127	136	145	156	167
Wood products	52	66	79	101	128	148
Other	81	97	110	128	148	167
Total	**3,986**	**4,631**	**4,818**	**4,866**	**5,018**	**5,228**

[1]These projections are the medium or "most likely" values projected in the navigation analysis. The Portland District's analysis also provided low ("likely minimum") and high ("likely maximum") values for each year.

The averages are computed across all three values for each year.

Source: U.S. Army Corps of Engineers, *Draft-Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement-Appendix I: Economics,* December 1999.

Similar to the UMR/IWS study, interests on all sides of the issue have stated concerns. The Corps, with the IEAB's reviews, has identified unresolved issues. Such unresolved issues (due to Corps sense of budget and time pressure) include:

1. Commodity forecasts do not reflect sources of the commodities in the Snake River hinterland.

2. Modeling logic and adjustments to the model are questioned by the IEAB as attempts to lower transport costs by assuming rational behavior by all shippers.

3. Truck costs in the model are too high; the errors have been identified, but no change was made.

4. Barge costs are too low, a factor that would offset the problem with the truck costs.

5. There are inconsistencies in truck long-haul distances and implications for backhaul.

6. Snake River elevators were assumed to close but, in fact, could serve as railroad shipping points.

7. Rates were used, rather than costs, for elevator storage and handling costs, while costs were solely used for modal shipments.

In summary, the increased transportation costs are important to shippers, averaging about 10 cents per bushel but ranging up to 26 cents per bushel on that grain that had been moved on the river prior to drawdown. Further, the estimates of ancillary impacts to the local economy are tentative at best. For example, the impact on State highways was originally estimated to be $156-$177 million. A more recent study, using the Eastern Washington Intermodal Transportation Study (EWITS) model from Washington State University, identified an additional $264-314 million in costs to local roads in counties in the region, for total impacts on all roads of $418-$491 million.

Whatever the final estimate, these costs have to be compared to the biological considerations of the Endangered Species Act. Initial analysis in 1998 indicated that none of the alternatives met all of the jeopardy standards. Dam breaching came closest to meeting all standards. Recent (1999) analysis incorporated new information on delayed mortality, ocean conditions, and ocean harvests. For fall Chinook, the only analysis completed at this time, all alternatives met the 24-year and 100-year survival standards, but only drawdown actions met the 48-year recovery standard. Nonbreaching actions do reach the 48-year standard but with a high level of uncertainty in relative survival of transported fish. In sum, in the newer analysis, the biological benefits of dam retention alternatives improve markedly, while the biological benefits of the dam breaching alternatives do not experience much change. The Corps concludes that all of the NMFS jeopardy standards can be met under dam retention alternatives and at substantially lower costs than under the dam breaching alternative.

It is these findings, along with the political debate that has since ensued, that have led to the

Federal caucus salmon/steelhead recovery strategy, released July 27, 2000, and the final draft of the Biological Opinion from NMFS and United States Fish and Wildlife to withhold further consideration of dam breaching for at least 5 and probably 10 years. Emphasis is on the 4 “h's”: hatcheries, habitat, harvest, and hydropower. The documents are to be finalized after a 60-day technical review by States, tribes, and interested parties.

There are many differences between the two studies reviewed in this chapter (see UMR/IWS versus Columbia River in the following): (1) build capacity versus stop operation; (2) with project as a capacity builder versus with project greatly constraining capacity; (3) environmental concerns of general river degradation versus restoration of specific endangered species; and (4) power production versus navigation. However, there are similarities as well. Will capacity be available? What will be the impact on farmers if capacity is lost as navigation decreases in priority? Environmentalist voices, societal desires, and cultural/treaty commitments with tribes are common, continuing, and strong elements in the debates.

Impact on Agriculture of Decreased Priority for Navigation

The impacts on agriculture of diminished navigation capacity, admitting greater priorities for alternative uses, takes the form of markets lost, increased costs of inputs, increased costs of getting products to market, differing production mixes, and lower profits from farming operations. All of these effects are manifested in price changes; the output price drops as the costs to access international markets increase, and input costs increase as distribution costs into the hinterland increase. The Corps estimates that users of the current Upper Mississippi River navigation system have saved as much as $13 per ton in transportation and handling charges on the annual movement of 137 million tons of cargo. Corn, soybean, and wheat shippers are estimated to save $9.58, $1.50, and $5.88 per ton, respectively, while fertilizer transport costs are lowered $8.03 per ton over alternative modes. It is these savings that are at risk as congestion costs increase with the projected traffic levels.

In an unpublished study by Fuller[8], extensive and detailed spatial equilibrium models were used to predict the impact on grain producer revenues of increased congestion costs on the Upper Mississippi/Illinois Waterway System and, after project improvements, the lower level of congestion costs. Using the contested projections from the Corps, he found alternative scenarios project revenues of grain producers to decrease by $365 million per year as production shifts and net market prices fall as a result of increased lock delay to 2020. (For example, producers in northwest Iowa and southeast and central Minnesota lose 15 cents per bushel). Extension of the seven locks and five guidewalls identified in the Corps preliminary draft would save producers about 47 percent of projected losses from increasing congestion delays. The rate activity of railroads before and after river improvements was found to have an important impact on benefits because it directly affects the elasticity of demand on the river.

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[8]Fuller, Stephen, *Effect on Grain Producer Revenues of Extending Lock Chambers and Guide Walls at Selected Locks on the Upper Mississippi and Illinois River*, unpublished manuscript, 2000.

The grower response to increased transportation costs generally depends on farming alternatives and the cost and availability of alternative transportation modes. Dryland farms, as compared to irrigated farms, have fewer alternatives. Thus, impacts could be more severe. The location of the farm relative to the river and river traffic patterns will also affect the impact of the higher transport costs. Finally, the nearby availability of alternative transportation may be the biggest factor in determining the magnitude of impact on agriculture.

Because of lack of market power, producers and land owners may appear to be residual recipients of the savings generated by the river improvements. It may be expected that barge companies will recover fully from shippers any net increase in transport costs caused by delay. The proposed savings in lock time (220-240 minutes for a one-way tow) would probably accrue directly to the barge operators. Exporters, country elevators, and any entity whose revenue is based on volume would also gain if the transport cost savings are reflected in higher commodity prices. It is also possible that some portions of the processing industry may be negatively affected by the higher price that must be paid for grain inputs, caused by competition with the international bulk markets. Suppliers selling into the processing market would also receive increased revenue with river improvements.

The question of "water-compelled" or competitive rate structures was introduced earlier. Those rates allow products to realize the benefits of low-cost water transportation without moving on the water. Corps analysis found that available water transportation constrains railroad rates any time the shipment origin is within 105 miles of the nearest waterway or the destination is within 40 miles of a river. Their initial study showed a reduction in railroad shipping charges of almost $22 million in 1 year for soybeans. Total value of water compelled savings for products commonly moved on the river, but moving by rail was over $1 billion per year. Other studies in the literature found the magnitude of the savings to be positive but more modest. While only an initial study and still under review by the Corps and outside reviewers, it does indicate some value has to be placed on the impact of "water-compelled" rates. Other studies of the industry have suggested a smaller impact might be seen.

In a related unpublished article, Vachal, Griffin, and Casavant examine the revenue and cost structure of alternative origin-destination shipments related to the Snake River issue (table 11). The competitive impact of available barge transportation in shipments from Idaho and Washington (revenue to fully allocated costs of about 82 percent), as contrasted to the movements from Montana and North Dakota to the same destinations (revenue to fully allocated costs of 123 percent for single car and 180 percent for unit trains), is evident in all rates. Such competitive rates are, indeed, felt in the country and received in the pocketbooks of producers.

Table 11. Rail revenue/cost ratios for selected Snake River market origins - single car shipments and unit train shipments, 1999.

Route	County	Rail carrier	Rail miles	Rail rate or revenue ($/car)	Fully allocated costs[1] ($/car)	Variable costs[1] ($/car)	R/VC ratio	R/FAC ratio
Idaho to Portland, OR - single car								
	Nez Perce	UP	386	$1,331	$1,714	$1,260	106%	78%
	Latah	BNSF	458	$1,331	$1,855	$1,359	98%	72%
	Idaho	BNSF	463	$1,442	$1,865	$1,367	105%	77%
	Boundary	BNSF	483	$1,620	$1,906	$1,396	116%	85%
	Boundary	UP	483	$1,325	$1,908	$1,402	95%	69%
Washington to Portland, OR - single car								
	Franklin	BNSF	234	$1,127	$1,399	$1,025	110%	81%
	Lincoln	BNSF	424	$1,507	$1,786	$1,308	115%	84%
	Spokane	BNSF	364	$1,338	$1,664	$1,219	110%	80%
	Chelan	BNSF	364	$1,464	$1,664	$1,219	120%	88%
	Spokane	BNSF	424	$1,457	$1,786	$1,308	111%	82%
Texas to Houston, TX - single car								
	Ellis	BNSF	206	$1,100	$1,342	$984	112%	82%
	Coleman	BNSF	336	$1,450	$1,607	$1,177	123%	90%

Table 11. Rail revenue/cost ratios for selected Snake River market origins - single car shipments and unit train shipments, 1999 (completed).

Route	County	Rail carrier	Rail miles	Rail rate or revenue ($/car)	Fully allocated costs[1] ($/car)	Variable costs[1] ($/car)	R/VC ratio	R/FAC ratio
Montana to Portland, OR - single car								
	Hill	BNSF	890	$3,610	$2,735	$2,003	180%	132%
	Lewis and Clark	BNSF	757	$2,789	$2,464	$1,805	155%	113%
ND to Portland, OR - single car								
	Stark	BNSF	1,324	$4,246	$3,619	$2,649	160%	117%
	Pierce	BNSF	1,366	$4,442	$3,705	$2,712	164%	120%
	Williams	BNSF	1,191	$4,276	$3,348	$2,451	174%	128%
ND to Portland, OR - Unit train (typical shipment configuration is unit train)								
	Stark	BNSF	1,324	$3,831	$2,207	$1,616	237%	174%
	Pierce	BNSF	1,366	$4,027	$2,270	$1,662	242%	177%
	Williams	BNSF	1,191	$3,861	$2,006	$1,469	263%	192%

[1]Fully allocated costs (FAC) includes the variable cost (VC) component attributed to a specific shipment and a "system" cost component that is shared among shipments originated by a carrier.

Source: Vachal, Kim, Gene Griffin, and Ken Casavant, *Implications of Breaching Lower Columbia-Snake River Dams on Modal Competition and Grain Flows*, Upper Great Plains Transportation Institute, North Dakota State University, UGPTI Staff Paper #145, March 2000.

Alternatives and Options

This discussion first reviewed the historical development of waterborne commerce in the United States, detailing the role played and success achieved by this low-cost, efficient mode of transportation. The unique combination of public investment and operating costs for infrastructure and the private operation of tow capacity on the river was addressed. The role of barge transportation in the total transportation system was reviewed. The new funding process of the IWTF was shown to be a harbinger of future demands by society for user participation in funding these investments. The current commodity profile and services provided on the river were combined with trade discussions to reaffirm the benefits offered from the river.

Specific attention was paid to issues surrounding navigation, broken into "perspectives" and "practices." The perspectives of international trade, feeding the world, and energy/emissions/environmental concerns were used to establish that the policy environment surrounding provision of navigation is a fluid one. Practices on the river were examined to help identify the complex and dynamic nature of the transportation system. Demand practices or issues included: the net impact of biotech on traffic; structured shifts in the landscape of production agriculture; capacity concerns in the railroad industry (near-term and long-term and short line railroads); and new international competition. All of these issues affect waterborne transportation somewhat differently, influencing the possible future traffic flows and need for river improvements. Supply issues include the capacity and degradation of facilities on the river system, the effect of NAFTA trade movements in the United States, and port infrastructure and development.

A significant amount of attention was given to two important Corps studies (Snake River and UMR/IWS) dealing with facilities needed for capacity enhancement or retention, with both studies experiencing the strong environmental/resource issues underlying multiple-purpose projects. Particular attention was given to the Corps' UMR/IWS study because of that river system's critical importance to agriculture in the Midwest. Corps findings were discussed within the context of expressed concerns about projections, elasticities, and environmental damages. Current suggestions for improving the analysis were also reviewed. The option of eliminating dams and attendant capacity on the Snake River as a means of restoring endangered salmon stocks in the region was also evaluated. Recent preliminary results indicate that nondrawdown options can achieve the same restoration standard as drawdowns and at a significantly lower cost.

Recent analysis by the Corps indicates that the IWTF can support all currently authorized projects completely on their current schedules. Several projects could be completed 1-4 years earlier than scheduled. Future projects, including the 1,200-foot lock extensions or replacements at selected Upper Mississippi and Illinois River locks, could be initiated at intervals beginning in 2008. The delay until 2008 is because the IWTF balance is projected to drop to only $35.5 million by 2007 due to "robust funding to capability levels.”

In a related issue, there is a possibility that the revenues can be increased if the current 4.3- cent "Deficit Reductions Tax" is diverted into the IWTF. This would increase fund revenues 20 percent, allowing construction of the Upper Mississippi-Illinois Rivers locks or other construction to commence 5 years earlier.

The waterborne transportation system is, indeed, an industry under economic and environmental siege. The environment in which navigation claims first (and, historically, only) priority of the waterways is changing dramatically. The public is now demanding that public investment actually reflect a full set of public interests–environmental, recreational, residential–and not simply commercial traffic and hydropower uses. Commercial users will either have to bear some greater cost share, in terms of improvements that reorganize and/or preserve other uses, or be prepared to accept higher costs to move products via alternative modes or lower net prices for higher cost movement without waterway improvements.

Options for the future of agricultural shippers and the agribusiness industry in the face of constrained capacity are varied but center on the concept of an entire transportation system. It could well be that adding waterway capacity could be an economic, if not always environmental, bargain relative to the cost of expanding capacity in the railway system. Capacity constraints on one subsystem (mode) have to be replaced in other subsystems (ports and rail). Methods of increasing railroad capacity and competition could include shipper-owned or State-owned cars, public support for short line railroads (avoiding road damage), improvement in amount and extent of all-weather rural roads and bridges, etc; in fact, any effort that fills the capacity voids should be investigated.

But, barge and marketing firms must also enter into the capacity-building effort along with the public sector. It appears barge and international marketing firms have accepted public investments as a substitute for providing some internal firm efficiencies. Issues of industry self-help at the locks, efficiency in individual tow tieups, scheduling of arrivals, and even congestion pricing may need to be discussed and instituted, as a near-term improvement in capacity and as a long-term capacity substitute, if navigation on the inland river system decreases as a societal priority.

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