Barge Traffic Disruptions and Their Effects on Shipping Costs in Agricultural Freight Corridors

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Center *for* Transportation Research

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EXECUTIVE SUMMARY

WHAT IS THE ISSUE AND HOW DOES THE REPORT ADDRESS IT?

Unplanned disruptions to the U.S. inland waterways system can impede the movement of grains and soybeans to domestic and export locations. Efficient transportation of these goods is important to U.S. competitiveness in the global agricultural market. Large volumes of grain and other commodities are shipped using the inland waterways system, which offers lower transportation costs per ton-mile than rail shipping for grain destined for export at central Gulf ports. Previous studies have examined the competitiveness between barge and rail service, focusing on the effect the availability of waterway shipping has on rates and market structure in the rail industry. This report explicitly investigates the effect on shipper costs and rail traffic associated with partial or total absence of barge services.

Grains produced in the upper Mississippi and Illinois River basins rely on a complex and competitive relationship between barge and railroad transportation to reach export markets in the Louisiana Gulf. However, the capacity of the rail network to accommodate a large and rapid increase in grain diverted from barge transportation due to disruptions on the inland waterways system is unclear. This study provides an extensive analysis of two navigation failure scenarios on the inland waterways and their impacts on grain transportation by barge and rail.

The movement of farm products from the upper Mississippi and Illinois River basins to export locations throughout the U.S. exemplifies a challenge that is inherent in all freight transportation. Competitiveness in global agricultural markets depends on the efficient transportation of agricultural goods. However, developing and operating freight networks that yield low transport costs can also mean sacrificing flexibility and resilience–two qualities that are also important to agricultural producers. Farm products must move affordably, but the freight networks for transporting them must also be dependable and able to accommodate rapidly changing demands. Ultimately, there is a tradeoff between cost-reducing transportation strategies and those designed to ensure a robust and responsive freight network.

The primary goal of this study is to understand the consequences of a major disruption at two network-critical locations on the inland waterways. Specifically, this analysis looks at (1) the ability of alternative inland waterways and the rail network to absorb displaced traffic by alternate truck-to-barge routes, rail-to-barge routes, or rail-all-the-way routes, and (2) quantifies the costs of these alternate routings.

HOW WAS THE REPORT CONDUCTED?

This report considers the impact of a disruption to one of two lock facilities used in waterborne transportation of grain destined for the Gulf coast, the LaGrange Lock and Dam on the Illinois River and Lock and Dam 25 on the Mississippi River, immediately above St. Louis. Each of these lock and dam facilities are critical to maintaining agricultural traffic on a length of a major waterway. A disruption at LaGrange would make it impossible for most grain shippers on the Illinois River to reach the Gulf or for up-bound fertilizer to reach the Illinois basin, but it would not affect the ability to ship on the upper Mississippi River (see first image). Likewise, an outage at Lock & Dam 25 would make it impossible for Mississippi River shippers above St. Louis to reach the Gulf by barge, but navigation on the Illinois River would still be possible (see second image).

Closure Scenario, Lock & Dam 25

Closure Scenario, LaGrange Lock and Dam

Source: The University of Tennessee

The study author evaluate the feasibility and cost of these disruptions using several transportation datasets. Barge data from the U.S. Army's Waterborne Commerce Statistics Center are used to model three situations of flows of down-bound grain traffic between the two study regions and the Louisiana Gulf. Using data from 1999 to 2017, the first situation looks at average down-bound grain flows across that period, the second situation includes these flows during 2017 (the latest year of data), and the third situation represents the maximum observed down-bound grain flows of the period (1999 for Lock and Dam 25; 2002 for LaGrange).

Rail data from the U.S. Surface Transportation Board's Carload Waybill Sample are combined with *RAILNET*, a GIS-based rail routing platform developed at the University of Tennessee, to model diversions from water to rail routings in response to the different barge scenarios. *RAILNET* uses a set of computational programs to realistically route rail traffic by minimizing system transportation costs.

For each of the three traffic flow scenarios, the analysis assumes an unscheduled 12-month closure at both locks to simulate a temporary but significant disruption to the inland waterways to measure the volume and transportation costs of displaced grain barge traffic. Furthermore, displaced barge traffic is assumed to seek alternate waterways access, to the extent there is excess terminal capacity along the waterways, before seeking rail access. The rail industry is assumed not to make significant investment in new network capacity due to the temporary disruption on the inland waterways. The author estimate the cost associated with increased truck miles by using the closest operational rail or barge facility.

WHAT DID THE REPORT FIND?

The simulations and computations determined that there would be significant cost increases associated from partial or complete loss of barge service in portions of the Mississippi and Illinois basins. These would be both in terms of cost, travel miles for the commodities, and overall volume shipped.

In an average year, a 12-month disruption to the LaGrange Lock and Dam would displace 12.4 million tons of grain. However, given the availability of alternative origin points for barge shipping on the Mississippi River, shippers could continue using barge shipments for the majority or all of these shipments, with increased trucking costs based on greater distance to these active barge terminals. If shippers were able to use alternative origins for barge shipments, the increase in cost associated with trucking the cargo to these new locations would total nearly $230 million in an average year. In a higher-traffic year such as 2017, the cost increase to shippers could be over $265 million, with rail absorbing 1.5 million tons of grain that was beyond the capacity of the barge terminals. In an extreme scenario where no alternative means of using barge exist, the cost increase due to rail-only shipping and other ancillary costs would total over $895 million.

A 12-month disruption to Lock and Dam 25 would result in a diversion of 18.5 million tons of grain. Because of the lack of nearby alternative barge terminals still in operation, there would be a greater need for rail services to compensate for the loss of waterborne traffic. Of the 18.5 million tons, 9.6 would need to use rail. However, if the diverted traffic equaled the maximum amount shipped via barge in the study period (which occurred in 1999), up to 28.5 million tons of grain would need to be routed using rail. In the average-traffic scenario, diversion costs could reach $720 million. Using 2017 traffic levels, the cost increase would be nearly $947 million. If there were no barge option, the cost increase would be nearly $1.8 billion.

The author's approach is conservative in several respects. It does not model an increase in rail or truck rates associated with the rise in demand if barge traffic is disrupted at these locations. Their simulations also allow for highly flexible deployment of personnel and equipment. Realistically, it may be more difficult for grain to be rerouted to rail in the immediate aftermath of a barge disruption, due to capacity constraints, particularly in the availability of train crews, who must be trained and certified to operate on specific routes. Railroads' ability to absorb this diverted barge freight is further complicated by the trend in rail operations toward lean, efficient service with little excess capacity or operational flexibility. It is uncertain to what degree rail routes and services would expand in response to transient increases in demand for rail service in the affected areas. Implementing new rail infrastructure and maintaining slack capacity is expensive. While an increase in rail rates may incentivize railroads to take on additional traffic and change their traffic patterns, railroads, in many cases, cannot adjust their rates fluidly to meet sudden changes in demand.

CONCLUSIONS

The findings suggest that a well-functioning lock and dam system in the inland waterways is crucial to maintaining low-cost grain transportation to and from the Mississippi and Illinois River basins. Disruption to these waterways will result in significantly higher costs for shippers and the potential for reduced flow of grain on the waterways.

PREFACE

The movement of farm products from the upper Mississippi and Illinois River basins to export locations throughout the U.S. exemplifies a challenge that is inherent in all freight transportation. Competitiveness in global agricultural markets depends on the efficient domestic transportation of agricultural goods. However, developing and operating freight networks that yield low transport costs can also mean sacrificing flexibility and resilience, two qualities that are also important to agricultural producers. Farm products must move affordably, but the freight networks for transporting them must also be dependable and able to accommodate rapidly changing demands. Ultimately, there is a constant tension between cost-reducing transportation strategies and alternative actions that would better ensure the availability of robust and responsive freight networks.

Resolving this tension and achieving a desirable balance between transportation efficiency and system strength and flexibility is an ongoing challenge. Meeting this challenge requires constant vigilance. It is within this context the work reported here examines the transportation network effects of unplanned disruptions to the nation's inland navigation system.

Not surprisingly, the results point to both strengths and vulnerabilities. The purpose in identifying and describing these varying degrees of capacity and resilience is not to advance any specific policy change. Rather, the aim is to clearly provide additional information to policy-makers and commercial leaders whose decisions combine to produce the transportation environment in which agricultural products move.

1. INTRODUCTION

Over the past two generations, and in the wake of regulatory reform, America's Class I railroads have significantly improved the efficiency with which they move freight. However, in doing so, the Class I carriers have also measurably reduced the extent of their networks, shedding tens of thousands of miles of main-line and branch-line track. In many cases, unwanted routes were sold to short-line railroads. In other cases, trackage was simply abandoned.[1]

While the efficiencies gained through these route "rationalizations" provided the means for Class I railroads to decrease costs and lower rates, reducing route miles also eliminated the redundancy and excess capacity that, historically, had been a source of flexibility and resilience. Indeed, one concern over the past two decades is that the nation's larger railroads now lack the ability to respond to unforeseen increases in demands for moving freight.[2]

Within this context it is, at least, possible that the railroads' pursuit of leaner route networks has added importance to preserving inland navigation system's reliability. Whereas, historically, the nation's railroads might have accommodated large volumes of waterway traffic diverted because of a navigation system outage, it is not clear the more efficient rail system of the 21st century has sufficient capacity to accommodate this sort of concentrated and rapid increase in rail freight demands.

In order to address this question, this study undertakes an extensive analysis of two navigation lock failure scenarios and their effects on the movement of grain from the upper Mississippi and Illinois River basins to export locations at the Louisiana Gulf. The first of these involves an unplanned closure of the LaGrange Lock & Dam on the lower Illinois River, immediately south of Beardstown, Illinois. The second scenario considers a similar closure of Lock & Dam 25 on the lower Mississippi River, near St Louis. In both cases, impacts are evaluated over a 12-month closure period.

The remainder of this project report is organized as follows: Section 2 describes the effects of rail industry regulatory reform and the resulting upper basin grain flows that are currently observed. The closure scenarios and resulting shipper behaviors are described in Section 3. Section 4 provides an analysis of terminal capacities both in the upper basins and at the Louisiana Gulf, while line haul railroad capacity is discussed in Section 5. Section 6 aggregates the cost implications described in earlier sections and final comments are offered in Section 7.

1 For a comprehensive discussion of railroad reform and its effects, see, Mark L. Burton, "Sustaining Balanced Policy: The Role of Economics in Post-Staggers Rail Rate Oversight," Journal of Transportation Law, Logistics & Policy, 2014, Vol. 82, No. 4, pp. 263-297.

2 See, William C. Vantuono, "Adding flexibility to the scheduled railroad," Railway Age, April 5, 2017, https://www.railwayage.com/freight/class-i/adding-flexibility-to-the-scheduled-railroad/

2. RAIL INDUSTRY REFORMS AND THE PATH TO OBSERVED UPPER BASIN GRAIN TRAFFIC

The competitive relationship between commercial navigation and railroad freight transportation is often both highly varied and complex. Nowhere is this reality more observable than in the movement of the grains produced in the upper Mississippi and Illinois River basins. Specifically, the waterways serve as a high-capacity, low-cost conduit linking the upper basin states to export markets via the Louisiana Gulf. The region's short-line railroads, and to a lesser extent, the Class I carriers, sometimes act as complements to the waterway, shuttling corn and soybeans from production locations to barge transload facilities on the Illinois and Mississippi Rivers.

More often, however, as distances to the waterway increase, Class I railroads are competitors, providing transportation alternatives to export locations in Texas or the Pacific Northwest (PNW). Moreover, on the margins, by adjusting their rates, the railroads have the ability to control the boundary separating the regions that ship by water from the regions that primarily rely on all-rail routings to reach export locations.

2.1 THE EFFECTS OF REGULATORY REFORM

Prior to 1976, the Interstate Commerce Commission (ICC) exercised complete control over nearly every aspect of rail commerce, including the development of rates. However, starting with the Railroad Revitalization and Regulatory Reform Act of 1976 (4R), Congress began to lessen the scope of railroad oversight and to reform the regulatory provisions that remained, so that, by 1983 after implementing key provisions of the Staggers Rail Act of 1980 (Staggers Act), railroads were considerably freer to determine when, where, and under what provisions they would provide service.[3]

Prior to regulatory reform, the ICC established railroad rates that protected inland navigation traffic from any threat of rail competition. Consequently, these rates were known as "umbrella rates." Regulatory reform ended this practice and made it possible for railroads to set rates and modify service offerings that directly reflect the influence of available navigation.

Regulatory reform had three important effects on the movement of export grain from the upper Mississippi and Illinois River basins. First, by sanctioning confidential contract rates and weakening the oversight of non-contract rates, the reforms significantly changed the way in which grain rates were set. Second, the noted changes reduced the burden railroads faced when they wished to sell or abandon a specific route. Finally, while the reform legislation made few specific changes to merger oversight, the ICC members who implemented the 4R and Staggers Acts adopted separate policies that helped accelerate Class I consolidations that eventually reduced the number of Class I railroads from roughly 20 to the seven that exist today.[4]

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3 See, Railroad Revitalization and Regulatory Reform Act of 1976, Pub.L. 94–210, S. 2718, 90 Stat. 31. As many will recall, the final piece of watershed reform legislation was the Staggers Rail Act of 1980 (Pub.L. 96-448, S. 1946, 94 Stat. 1895). In 1983, with its introduction of Constrained Market Pricing (CMP), the ICC took the final steps necessary to fully implement the Staggers Act.
4 See Frank N. Wilner, Railroad Mergers: History Analysis Insight, Simmons-Boardman, Omaha, Nebraska, 1997.

In a practical sense, these changes in railroad oversight have had easily understandable manifestations. Where railroads can compete effectively with waterways, they do so. Again, this is at the geographic margin where trucking distances to the waterway are sufficiently long to diminish some or all of navigation's natural economic advantage.

Next, either through abandonment or line sale, U.S. Class I railroads reduced network route miles by nearly 43 percent (184,000 to 106,000) between 1976 and 1996. At the same time, the number of short-line railroads has grown from roughly 200 in 1980 to approximately 600 today. In Iowa, alone, there are currently 13 short-line railroads, though in some cases, one Class III carrier (short-line) is owned by another.

Finally, the pattern of consolidation extended the ability of both the Union Pacific and BNSF to provide single-line, all-rail connections between the study region and alternative export locations (Texas or the PNW). For this reason, the mergers that produced the current-day UP and BNSF reduced the incentives these Class I carriers have to participate in rail-water, Gulf-bound grain shipments.[5]

2.2 CURRENT STUDY REGION RAILROAD EXPORT GRAIN TRAFFIC

There are three relevant export grain corridors that affect (or can affect) traffic flows from the study region. These include the corridor from the upper basin states to the Louisiana Gulf, a second corridor that connects the upper Midwest and Plains states to export destinations in Texas, and a third corridor that connects the upper Midwest and Plains states to ports in the PNW. These corridors are depicted in Figure 1. Figure 2 provides a closer view of the study region (the area enclosed by the dotted line) as it relates to the three corridors and also indicates the portion of the region where water-inclusive transportation alternatives dominate available all-rail routings to export locations.

Even these rough depictions yield considerable information. For example, much of Wisconsin lies outside the three corridor regions. This reflects the influence of available Great Lake shipping. Also, in past decades the Missouri River influenced railroad rates and rail flows. However, based on environmental concerns, Missouri River flows are now managed to mimic the river's natural hydrograph. As a result, commercial navigation is often unavailable as a transportation alternative.[6]

Finally, while railroads do not have the ability to affect export destinations for areas within the waterways' influence, they can shift boundaries between corridors for areas that are more distant from the river. This is done by changing relative rail rates for shipments to the Texas Gulf and to the PNW. This practice allows the railroads to rebalance traffic on their systems in response to changing demands elsewhere.

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[5] See, Mark L. Burton and Wesley W. Wilson, "Network Pricing: Service Differentials, Scale Economies, and Vertical Exclusion in Railroad Markets," *Journal of Transport Economics and Policy*, May 2006.

[6] To understand the early post-Staggers relationship between Missouri River navigation and rail rates see, "Rail Rates And The Availability Of Water Transportation: The Missouri Valley Region, "*The Review of Regional Studies*, Vol 25, No 1 (1995), pp. 79-95. A similar (unpublished) exercise in 2014 revealed that all water compelled effects had disappeared.

Figure 1 – Relevant Export Grain Corridors

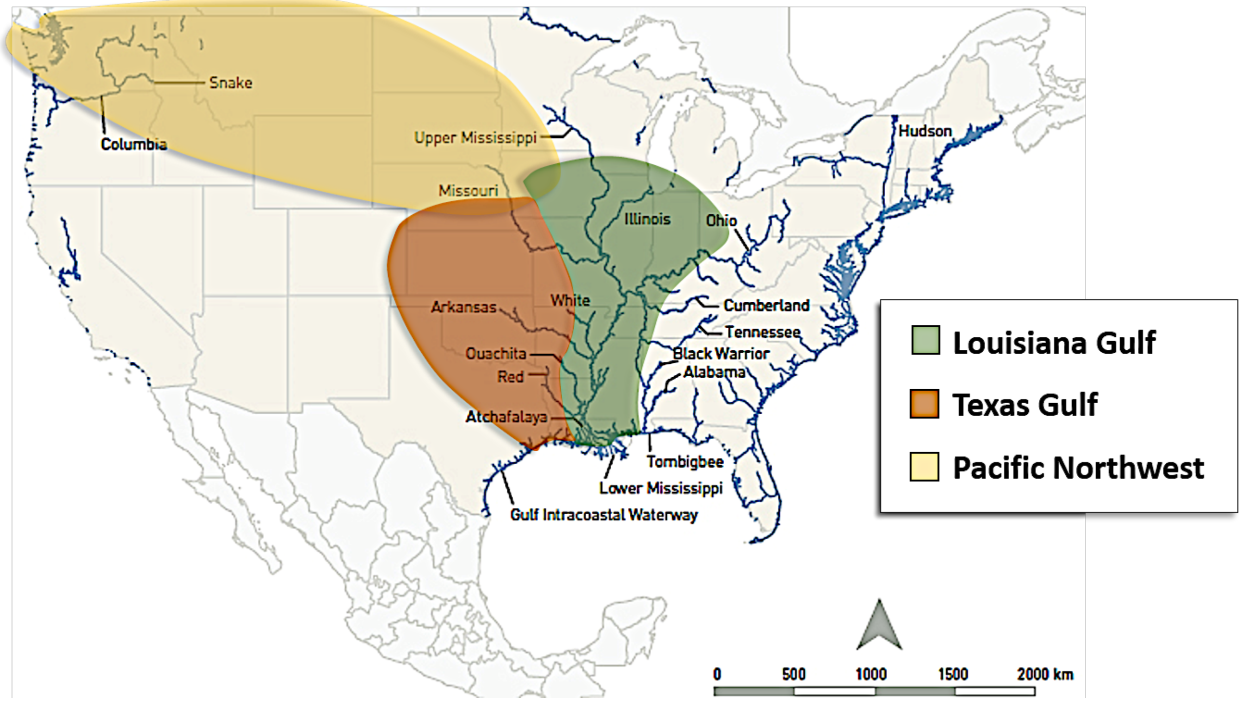


Figure 2 – The Study Region and Export Relevant Export Grain Corridors

Source: The University of Tennessee

Tables 1 through 3 add further information. Table 1 details 2015 rail traffic originating from the study region states. On the whole, farm products accounted for roughly 10 percent of originating traffic, with higher shares in Iowa and Minnesota. Among farm products, corn is the dominant commodity, with over 100,000 cars originating each in Illinois and Minnesota. However, not all of the corn was bound for export. In fact, the data suggest that, across the study region, roughly 15 percent of corn movements were bound for ethanol facilities within the region.

Table 2 provides combined destination state totals for all grain shipments originating in the five study region states. In terms of total farm product traffic California and Washington lead as destinations. With a combined total of nearly 300,000 carloads, these two destination states account for more than 40 percent of the farm product shipments originating in the study region.

Turning to individual commodities, Washington is still the dominant terminus for corn in the study region. However, Texas and Illinois are also important destinations.[7] Rather than moving west, rail shipments of wheat in the study region are headed to eastern markets, likely domestic shipments to milling facilities. For wheat, Illinois, New York, and Pennsylvania are the leading recipients. As with corn and all farm products, Washington is the dominant recipient of soybeans. Illinois ranks second and Louisiana is third.

Finally, Table 3 provides carload totals for railroad traffic that terminated in Louisiana, Texas, Oregon, and Washington, the four states that anchor the export end of the three corridors described above. Among these four states, Washington was the largest recipient of farm products, terminating nearly as many carloads as the three other states combined. Moreover, farm products represented nearly one third of the total carloads terminated there in 2015.

7 Readers should treat Illinois totals cautiously. As with nearly all commodities, grain shipments are often billed to Chicago on one waybill and billed to a subsequent destination on a second waybill. Thus, while Illinois often appears as a prominent origin or destination, it is often only a transition point in shipments that neither originate nor terminate there.

Table 1 – Originating Study Region Traffic (2015 Carloads)

	Iowa	Illinois	Minnesota	Missouri	Wisconsin	TOTAL
Other Crops	1,732	174,900	15,656	2,444	3,996	198,728
Corn	86,504	126,127	101,900	24,317	22,303	361,151
Wheat	884	53,874	20,803	5,122	4,680	85,363
Soybeans	26,747	36,164	47,278	6,346	6,786	123,321
Coal	31,242	421,529	1,198	300	0	454,269
Bulk Commodities	25,674	201,641	494,698	65,682	158,147	945,882
Processed Goods	177,914	596,481	109,587	68,862	33,964	986,808
Non-Liquid Chemicals	8,848	219,947	15,701	26,212	12,021	282,729
Tank Car Traffic	246,079	395,998	94,559	25,228	26,190	788,054
Automobiles and Parts	560	491,560	1,040	153,880	160	647,200
Intermodal	20,680	2,662,800	103,640	179,360	8,080	2,974,560
Other	10,614	480,214	19,356	35,276	3,851	549,311
TOTAL	637,478	5,861,235	1,025,416	593,029	280,178	8,397,376
Total Farm Products	115,867	391,065	185,637	38,229	37,765	768,563
Farm Product Share	18.2%	6.7%	18.1%	6.4%	13.5%	9.2%

Source: 2015 Carload Waybill Sample

Table 2 – Terminating States for Study Region Grain Traffic (2015 Carloads)

State	Corn	Wheat	Soybeans	Other Crops	TOTAL
Alabama	4,986	580	1,572	40	7,178
Arizona	8,714	566			9,280
Arkansas	4,803				4,803
California	27,763	888	11,920	111,640	152,211
Colorado	80			288	368
Connecticut	240				240
Delaware	308				308
Florida	3,340	4,192		1,600	9,132
Georgia	19,398	1,176	1,278	640	22,492
Idaho	3,744				3,744
Illinois	36,650	14,624	20,404	2,508	74,186
Indiana	12,855	6,544	1,545	120	21,064
Iowa	17,857	1,104	6,537	1,784	27,282
Kansas		232	40	280	552
Kentucky		264	648	320	1,232
Louisiana	10,805		16,190		26,995
Maryland	40		40	360	440
Massachusetts		916	40	4,880	5,836
Michigan		644		40	684
Minnesota	8,932	3,496	4,908	5,224	22,560
Mississippi	13,816	36		80	13,932
Missouri	2,278	2,803	6,880	220	12,181
Montana	160				160
Nebraska	228	576		40	844
Nevada	284		80		364
New Jersey		2,072		10,240	12,312
New Mexico	3,452		40	76	3,568
New York	1,672	10,578		5,660	17,910
North Carolina	8,332	4,880		760	13,972
North Dakota	120	288		220	628
Ohio	160	3,057		760	3,977

Oklahoma	2,998			80	3,078
Ontario	448		220	1,440	2,108
Oregon	3,907		1,264	200	5,371
Pennsylvania	2,133	8,704	200	4,636	15,673
South Carolina	3,219	1,584		436	5,239
Tennessee	9,443	2,584		880	12,907
Texas	36,663	1,069	1,012	1,932	40,676
Utah	1,160				1,160
Virginia	2,064	7,655	1,280	1,240	12,239
Washington	63,302	120	37,151	36,040	136,613
Wisconsin	8,188	3,594		2,344	14,126
Canada	240	0	240	1,560	2,040
Mexico	8,956	537	1,740	160	11,393

Source: 2015 Carload Waybill Sample

Table 3 – Terminating Railroad Traffic (2015 Carloads)

	Louisiana	Texas	Oregon	Washington	TOTAL
Other Crops	622	2,100	54,612	49,528	106,862
Corn	14,187	7,369	63,514	135,161	220,231
Wheat	1,336	27,568	71,283	52,364	152,551
Soybeans	29,631	6,154	9,568	135,761	181,114
Coal	50,828	7,126	359,211	36,404	453,569
Bulk Commodities	63,054	63,802	642,705	118,053	887,614
Processed Goods	42,167	68,182	326,649	90,133	527,131
Non-Liquid Chemicals	90,708	65,317	248,486	19,185	423,696
Tank Car Traffic	206,665	22,792	394,824	131,941	756,222
Automobiles and Parts	47,240	26,720	265,800	28,360	368,120
Intermodal	73,000	98,240	801,760	283,840	1,256,840
Other	40,043	41,248	229,415	50,762	361,468
TOTAL	659,481	436,618	3,467,827	1,131,492	5,695,418
Total Farm Products	45,776	43,191	198,977	372,814	660,758
Farm Product Share	6.9%	9.9%	5.7%	32.9%	11.6%

Source: 2015 Carload Waybill Sample

2.3 CURRENT STUDY REGION WATERBORNE EXPORT GRAIN TRAFFIC

The two disruption scenarios focus on LaGrange Lock & Dam on the lower Illinois River and Lock & Dam 25 on the upper Mississippi River, immediately north of the Illinois River's confluence with the Mississippi, just above St Louis. Therefore, the relevant traffic consists of down-bound grain movements through both locations. These movements, as captured by the 2014 Waterborne Commerce Statistics Center (WCSC) data, are summarized in Tables 4 and 5. Totals from these tables indicate 11 million tons for LaGrange and 12 million tons for Lock & Dam 25. As a rough comparison, in 2016, the total volume of farm products railed between all five study region states and the state of Louisiana totaled slightly less than three million tons.[8]

Table 4 – Originating Down-Bound Farm Products, LaGrange Lock & Dam (2014 Tons)[9]

State	Origin County	2014 Total
ILLINOIS	LaSalle	2,038,084
	Peoria	636,205
	Putnam	1,089,289
	Tazewell	1,335,511
	Will	22,300
	Other	5,864,841
	State Tons	10,986,230

Source: 2014 Waterborne Commerce Statistical Center (WCSC) Data

[8] Because of the study's duration and the timeframe in which data elements became available, our analysis sometimes mixes data from differing years. In the current setting, doing so does not affect the analysis.
[9] In cases where there were three or more shippers from an origin county, county totals are provided. Otherwise, originating tonnages are combined as "Other."

Table 5 – Originating Down-Bound Farm Products, Lock & Dam 25 (2014 Tons)[10]

State	County	2014 Total
IOWA	Clayton	450,649
	Des Moines	777,258
	Dubuque	541,321
	Lee	359,267
	Muscatine	290,816
	Scott	723,147
	Other	576,176
	State Total	3,718,634
ILLINOIS	Adams	1,053,051
	Henderson	484,685
	Other	2,122,209
	State Total	3,659,945
MINNESOTA	Goodhue	332,974
	Winona	489,038
	Other	1,794,016
	State Total	2,616,028
MISSOURI	State Total	1,150,193
WISCONSIN	State Total	766,868
REGIONAL TOTAL		11,911,668

Source: 2014 WCSC Data

2.4 SUMMARIZING COMBINED RAIL AND BARGE TRAFFIC

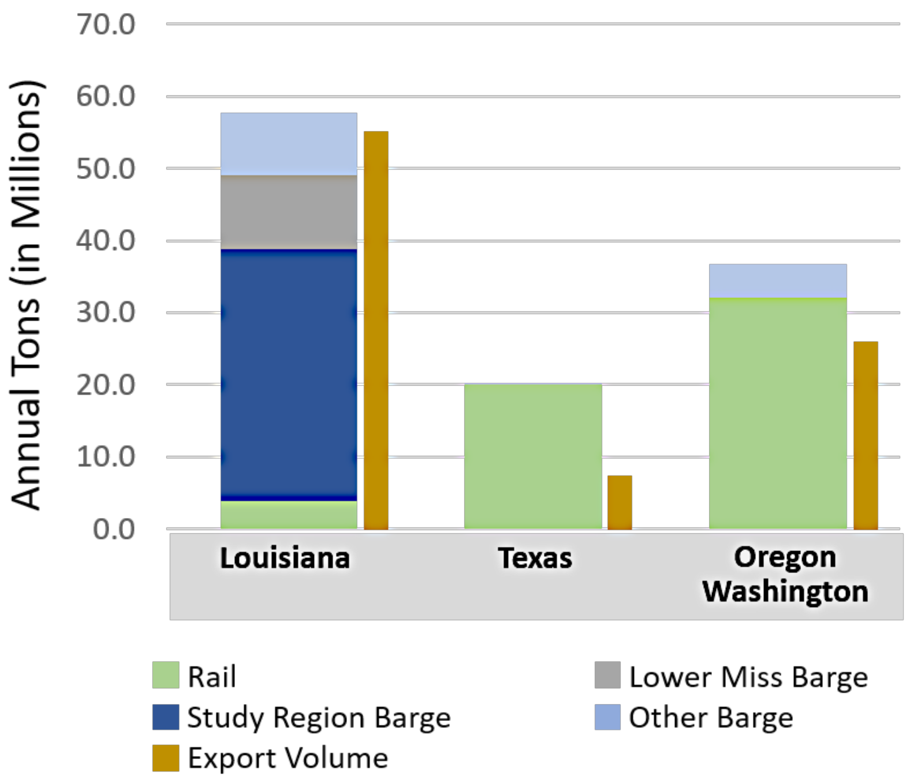
There are numerous lenses to view export grain traffic from the upper Mississippi and Illinois River basins. However, the view provided in Figure 3 (and the corresponding Table 6) is the clearest. For purposes of this analysis, there are three major grain exporting locations—the Louisiana Gulf, the Texas Gulf, and Pacific Northwest (PNW). Among the three, the Louisiana Gulf is the biggest exporter of farm products, the PNW is the second largest, and the Texas Gulf is relatively small.

Most of the export grain grown in the five study states is barged to Louisiana. Smaller portions are delivered by rail to all three export regions. The waterborne grain makes up most of

[10] In cases where there were three or more shippers from an origin county, county totals are provided. Otherwise, originating tonnages are combined as "Other".

the Louisiana total, while most of the grain reaching the PNW and Texas Gulf is delivered by rail. Finally, the proportion of grain reaching Texas that is *not* exported is considerably larger than for the PNW or Louisiana. Given that the Texas population of 28.3 million dwarfs the populations of Louisiana, Washington, and Oregon (4.7, 7.4, and 4.1, respectively), this outcome is not surprising. The difference may also be attributable to the relative amounts of animal feed consumed in each state.

Figure 3 – Summary of Relevant Rail and Barge Grain Flows



Sources: CWS, WCSC Data, Port Import Export Reporting Service (PIERS)

Table 6 – Summary of Relevant Rail and Barge Grain Flows (Tons In Millions)

Export Region	Louisiana Gulf	Texas Gulf	Pacific Northwest
RAILED TO REGION	3.8	20.0	32.0
Barged from Study States to Region	35.1	0.0	0.0
Barged from the Lower Miss to Region	10.2	0.0	0.0
Barged from Other Waterway to Region	8.6	0.1	4.7
BARGED TO REGION	53.9	0.1	4.7
TOTAL REGIONAL INFLOW (EXC. TRUCK)	57.7	20.1	36.7
2017 Export Volume	56.6	7.5	26.3

Sources: CWS, WCSC Data, Port Import Export Reporting Service (PIERS)

3. DISRUPTION SCENARIOS AND SHIPPER RESPONSES

The primary goal of the analysis is to better understand the consequences of a major disruption at a network-critical location on the inland waterway. It follows that the investigation considers two failure scenarios, one at LaGrange Lock & Dam on the Illinois River and one at Lock & Dam 25 on the upper Mississippi immediately above St. Louis.

3.1 THE LOCKS AND THEIR NETWORK ROLE

Tables 7 and 8 detail the 2017 tonnages locked at each location. Figure 4 depicts the locations of the locks that are the subject of each scenario. The work reported here is the third in a series of studies focusing on service disruptions at these locations.[11] These locks continue to attract attention because each is critical to a specific and important segment of agricultural commerce. A disruption at LaGrange would make it impossible for most waterway grain shippers on the Illinois River to reach the Gulf or for up-bound fertilizer moves to reach the Illinois basin, but would not affect the ability to ship on the upper Mississippi. Likewise, an outage at Lock & Dam 25 would make it impossible for Mississippi River shippers above St Louis to reach the Gulf by barge, but navigation on the Illinois River would still be possible. There are only two locks below the confluence of the Illinois and Mississippi Rivers (Melvin Price and Locks & Dam 27) and an outage at either of these locations would block shippers on both the upper Mississippi and the Illinois from waterway access to and from the Gulf. As will be discussed below, shipper access to an alternative waterway (the upper Mississippi in the case of a LaGrange outage and the Illinois in the case of a disruption at Lock & Dam 25) is an important element in predicting how waterway users would respond to an unplanned lock closure.

[11] See, Yu, T.E, B.C. English and R.J. Menard. Economic Impacts Analysis of Inland Waterway Disruption on the Transport of Corn and Soybeans. Staff Report #AE16-08. Department of Agricultural and Resource Economics, University of Tennessee. September 2016. Also see, Mark Burton and Craig Philip "The Impacts of Unscheduled Lock Outages," National Waterways Foundation and U.S. Maritime Administration, October 2017 available at: http://www.nationalwaterwaysfoundation.org/documents/low%20res%20Lock%20Outage%20NWF_FINAL_REPORT%202017.pdf.

Table 7 – 2017 LaGrange Lock & Dam Traffic (Tons)

Commodity	Up-Bound Traffic	Down-Bound Traffic	TOTAL
Coal	149,600	470,500	620,100
Petroleum	1,014,500	2,807,300	3,821,800
Chemicals	3,876,900	2,284,800	6,161,700
Crude Materials	1,844,300	1,139,400	2,983,700
Processed Materials	2,657,900	408,000	3,065,900
Farm Products	502,400	11,473,300	11,975,700
Manufactured Equipment	21,800	35,900	57,700
Waste Materials	4,800	6,100	10,900
Other	19,300	34,900	54,200
TOTAL	10,091,500	18,660,200	28,751,700

Source: LPMS Data

Table 8 – 2017 Lock & Dam 25 Traffic (Tons)

Commodity	Up-Bound Traffic	Down-Bound Traffic	TOTAL
Coal	299,400	4,600	304,000
Petroleum	140,400	146,400	286,800
Chemicals	4,088,300	697,400	4,785,700
Crude Materials	1,615,700	437,100	2,052,800
Processed Materials	1,115,700	605,900	1,721,600
Farm Products	281,100	22,038,700	22,319,800
Manufactured Equipment	38,000	53,700	91,700
Waste Materials	0	0	0
Other	4,800	3,200	8,000
TOTAL	7,583,400	23,987,000	31,570,400

Source: LPMS Data

Figure 4 – The Location of LaGrange Lock & Dam and Lock & Dam 25

As will be further discussed below, the 2017 grain traffic over Lock & Dam 25 was particularly high. In more typical years, the agriculturally-related traffic at the two locks is similar, where both locks will see 10-14 million tons of down-bound corn and soybeans and four million tons of up-bound fertilizer ("chemicals" in Tables 7 and 8). Generally, the only consistent difference is a higher volume of industrial products (chemicals, steel, etc.) and petroleum, moving to and from Chicago area markets.

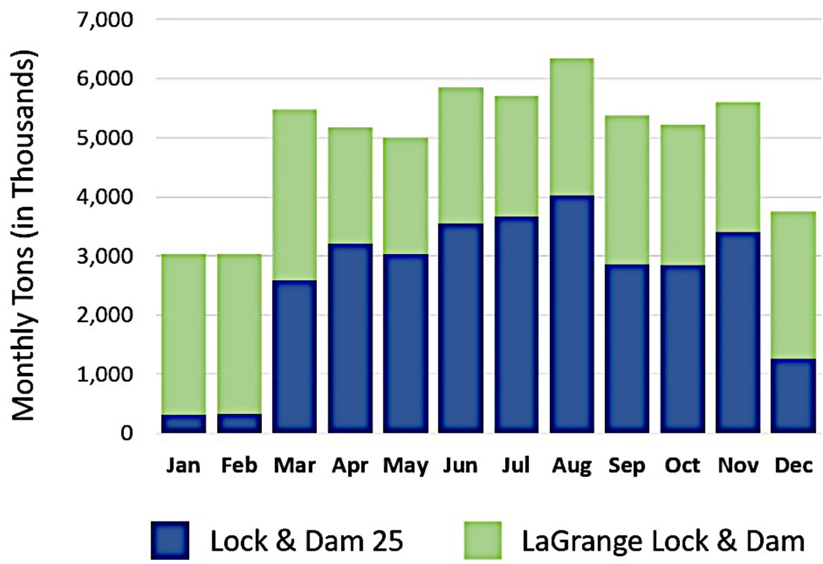
3.2 THE DISRUPTION SCENARIOS

By design, the disruption scenarios are very simple. The analysis first assumes an unscheduled 12-month closure at LaGrange, then traces shipper responses and transportation consequences. When this exercise is complete, it is repeated for an identical closure at Lock & Dam 25.

While there have been planned closures of more than a year, an unplanned closure with a 12-month duration would be a rare event. However, simulating a planned closure is significantly more complex. Faced with a planned closure, shippers could stockpile inputs and, in the case of grain shippers, build, or otherwise secure, additional storage. Similarly, if railroads could anticipate an increase in demand, they could qualify additional crews, acquire additional equipment, and perhaps, make modest investments in improved infrastructure.[12] Scenarios involving planned closures would need to account for each of these factors.

The use of a closure that is 12-months in duration eliminates the need to account for seasonality. The effects of an unplanned closure would be significant regardless of the closure's timing. However, the effects of a six-month outage would vary considerably depending on which specific months the subject lock is closed. Moreover, these seasonal variations would differ between the two locks considered here. Figure 5 shows total monthly tonnages for LaGrange and Lock & Dam 25. This figure graphically illustrates the complexity inherent in considering anything less than a 12-month closure. Nonetheless, our failure to account for seasonality does, to a degree, limit the applicability of the study's findings.

Figure 5 – Seasonality at LaGrange Lock & Dam and Lock & Dam 25 (2017)



Source: LPMS Data

3.3 SHIPPER RESPONSES

If the study scenarios are remarkably simple, the nature and magnitudes of possible shipper reactions to an unplanned closure are extraordinarily complex. The extent to which alternatives are adopted by affected shippers will vary between the two scenarios. Nonetheless, there are several basic assumptions that are common to the treatment of both and which are fundamental to understanding the incremental demands that may be faced by the region's railroads. These assumptions are first enumerated then further considered. Assumptions include:

[12] Whether planned or otherwise and almost without regard to duration, railroads are unlikely to make significant investments in infrastructure unless the lock closure is permanent. Railroad network assets are largely sunk and have lives that are measured in decades. It would be wholly irrational for railroads to make such investments in response to a transient increase in demands.

1. Increased local consumption will not absorb a meaningful amount of the grain volumes displaced by an unplanned lock closure;
2. Shippers will first look for alternatives that keep traffic on the waterways;
3. Waterborne alternatives are available, but are limited by trucking distances and capacity at river terminals which can be increased by as much as 42 percent on the Illinois River and as much as 56 percent on the upper Mississippi;[13]
4. While rates would likely increase, and localized congestion could be an issue, additional motor carriage would be available as required.

Local Consumption

The five-state study region is home to a significant amount of local consumption in the form of livestock feeding, ethanol production, and soybean processing. A disruption in available navigation would place downward pressure on local grain prices and likely lead to an observable increase in local consumption. However, actual quantities are likely to be small in comparison to the amount of newly available grain.

Barge vs. Rail

Table 9 provides rate calculations for hypothetical rail and barge movements from mid-state Illinois to the Louisiana Gulf. Parameter values were gleaned from a variety of sources. This suggests that Illinois grain shippers would be willing to truck their output an additional 138 miles (or a total of 178 miles) to reach a barge-served alternative terminal.[14] Moreover, while the estimated values vary some, the same general conclusion can be extended to shippers in Iowa, Minnesota, Missouri, and Wisconsin. Moreover, even if burgeoning demand increased trucking prices by one-third, regional grain shippers would still be willing to incur an extra 103-mile shipment distance in order to access the waterways.

Barge Terminal Capacity

Accurately tallying the barge terminal capacities along the Illinois and Mississippi Rivers within the five study states is beyond the scope of our analysis. Still, evaluating the effects of an unplanned lock closure on regional rail traffic requires an accounting for water-served terminal capacity.

Toward this end, Table 10 reports the down-bound grain loaded on the Mississippi River above Lock & Dam 25 and the down-bound grain loaded at Illinois River terminals above LaGrange Lock & Dam for the years 1999-2017. These data suggest a tremendous variation in the annual activity over the corresponding terminals. On the Illinois, above LaGrange, totals range between 6.6 million and 17.9 million tons. On the Mississippi above Lock & Dam 25, the annual range is between 8.5 and 28.5 million tons. Regarding capacity, these data, if nothing else, suggest that, in an average year, there is surplus terminal capacity on both waterways—at least, 5.4 million tons on the Illinois and 10.0 million tons on the Mississippi above St Louis.

[13] These percentages reflect the difference between current (2017) volumes and the maximum volumes recorded in the period between 1999 and 2017.
[14] The total trucking distance is determined by equalizing the total line-haul charges for the rail versus water alternatives. (If the distances are any greater, the water alternative would be more expensive than the rail alternative, even though the waterway leg is always cheaper.)

Trucking Capacity

Most of the grain traffic that currently moves on subject waterways reaches barge-served terminals by truck. Moreover, anecdotal information suggests that some of this grain travels distances of up to 100 miles. Trucking distances for grain flows to regional consumers are at least as great. There is already a tremendous amount of trucking capacity within the study region. Moreover, unlike train crews, truck drivers do not have to be qualified over specific territories. Economic theory suggests that securing additional driver capacity by attracting additional drivers or paying overtime wages to existing drivers would increase regional trucking costs (probably by a significant amount), but securing any necessary trucking capacity would almost certainly be possible.

Table 9 – Hypothetical Rate Calculations

Barge Movement			Rail Movement		
TRUCK TO RIVER			TRUCK TO ELEVATOR		
Average Miles	40		Average Miles	20	
Lading Weight	20		Lading Weight	20	
Ton-Miles	800		Ton-Miles	400	
TM Truck Rate	$0.17		TM Truck Rate	$0.17	
Truck Cost per Ton		$6.80	Truck Cost per Ton		$3.40
UNLOAD		$2.00	UNLOAD		$2.00
RELOAD		$1.50	RELOAD		$1.50
BARGE LINE-HAUL			RR LINE-HAUL		
Average Miles	1,500		Average Miles	1,050	
Lading Weight	1,500		Lading Weight	115	
Ton-Miles	2,250,000		Ton-Miles	120,750	
TM Barge Rate	$0.01		TM Rail Rate	$0.04	
Barge Line-Haul Cost		$15.00	Rail Line-Haul Cost		$42.00
TOTAL		$25.30	TOTAL		$48.90

Source: The University of Tennessee

Table 10 – Grain Tonnage on the Subject Waterways

Year	LaGrange	Lock & Dam 25
1999	17,265,261	28,507,755
2000	16,275,063	26,193,793
2001	17,055,804	22,927,973
2002	17,858,665	27,172,372
2003	16,594,977	22,349,908
2004	14,001,220	16,784,665
2005	12,090,075	16,617,658
2006	12,601,367	18,926,126
2007	11,838,092	18,584,302
2008	9,874,133	12,820,899
2009	11,412,747	17,096,751
2010	11,483,421	15,274,530
2011	9,757,894	13,643,310
2012	8,566,719	13,927,272
2013	6,607,911	8,457,467
2014	9,775,973	11,292,154
2015	9,157,172	16,066,195
2016	12,448,764	22,509,356
2017	11,473,000	22,038,700
Mean	12,428,329	18,483,747
Maximum	17,858,665	28,507,755
Difference	5,430,336	10,024,008

Source: LPMS Data

3.4 POTENTIAL RAIL TRAFFIC: THE LAGRANGE SCENARIO

Figure 6 depicts the Illinois River terminals that would be isolated from the Gulf of Mexico by a closure of LaGrange Lock & Dam. It also shows the locations of the Illinois and Mississippi River terminals that would retain Gulf access.

Assuming average years on both systems, an unplanned closure at LaGrange would displace roughly 12.4 million tons of grain (Table 10). Again assuming average conditions, Table 10 suggests that 10.0 million tons could be absorbed by Mississippi River barge-served terminals in Illinois, Iowa, and southern Minnesota. The remaining 2.4 million tons could likely be trucked south to St Louis at costs that still favor a truck-barge alternative over an all-rail routing. These outcomes would, however, increase transportation costs by nearly $23 million and result in billions of additional truck ton-miles, mostly on Illinois roadways.[15]

Three points are worth noting. First, and not surprisingly, the data in Table 10 indicate that grain traffic through LaGrange and grain traffic through Lock & Dam 25 are highly correlated over time. Second, not all years are average years. For example, suppose the scenario year had been in 2017 instead. Continuing the assumption the recorded maximum on the Mississippi represents full capacity, the residual capacity on the upper Mississippi in 2017 would have only equaled 6.5 million tons (28.5 million ton maximum less 22.0 million tons moved in 2017). If East St Louis and Cahokia, IL can absorb an additional 2.5 million tons and elevators below LaGrange capture an additional 1 million tons, these outcomes would have forced 1.5 million tons of grain toward all-rail diversions.[16]

Figure 6 – Closure Scenario, LaGrange Lock & Dam

Source: The University of Tennessee

[15] The $23 million value was derived by multiplying the more than 240 million additional truck ton-miles by a truck rate of 9.5 cents per ton-mile.
[16] The three locations below LaGrange include Meredosia, Naples, and Florence which, in 2014, loaded a combined total of 957,000 tons of grain. The residual 1.5 million tons (mt) comes from 11.5 mt through LaGrange in 2017 less 6.5 mt diverted to the Mississippi, less 2.5 mt sent to East St Louis and Cahokia, IL, and less 1 mt to locations below LaGrange.

3.5 POTENTIAL RAIL TRAFFIC: THE LOCK & DAM 25 SCENARIO

Figure 7 depicts the Mississippi River terminals that would be isolated from the Gulf of Mexico by a closure, as well as the Illinois and middle-Mississippi terminals that can function as alternatives. The geographic reach of a Lock & Dam 25 closure is considerably wider than the Illinois River disruption. Traffic in all five study-region states would be affected.

As in the case of the LaGrange scenario, affected shippers would almost certainly seek a water-served alternative. The assumption here is that Illinois shippers along the upper Mississippi would route traffic via the Illinois River, as would shippers in eastern Iowa. As in the first scenario, water-served terminal capacity—this time on the Illinois River—would likely be a determinant of how much grain would necessarily require an all-rail routing.

A comparison of the recorded maximum quantity of grain shipped via Illinois River ports (from locations above LaGrange) contained in Table 10, combined with the modest capacity at three Illinois River locations below LaGrange and a potential 2.5 million-ton capacity at East St Louis, suggests that, in total, there is 8.9 million tons of excess capacity in the Illinois basin in an average year.[17] The average down-bound grain transiting Lock & Dam 25 is 18.5 million tons (Table 10), so that under average conditions, a closure of the subject lock would push 9.6 million tons of mostly corn and soybeans toward all-rail routings.[18] Further, it is nearly certain that rail rates would be higher under the increased demand. Our estimates suggest that rail network congestion costs would increase rates by 10 percent and this 10 percent value does not include the additional costs of repositioning crews and equipment. The 10 percent value also ignores the additional market power that would accrue to the railroad in the absence of water navigation.

Again, however, every year is not average. Had the scenario year been 2017, the displaced grain tonnage to railroads would have been 12.1 million tons.[19] In an extreme case, assuming that Illinois River terminals were at full capacity, had the outage occurred in 1999, 28.5 million tons of upper basin grain would have sought an all-rail routing.[20]

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[17] The 8.9-million-ton value is derived from 5.4 million tons of (average) capacity above LaGrange, 2.5 million tons in East St Louis, and 1 million tons below LaGrange.
18 Assuming 110 tons per car, this tonnage would be roughly equivalent to 785 110-car unit trains.
19 The 12.1-million-ton value is derived from 22.0 million tons through Lock & Dam 25 in 2017, less 6.4 million tons of capacity above LaGrange (in 2017), less 2.5 million tons in East St. Louis, and less 1 million tons below LaGrange.
20 Or about 1,000 and 2,355 110-car unit trains, respectively.

Figure 7 – Closure Scenario, Lock & Dam 25

Source: The University of Tennessee

3.6 CLOSURE SCENARIOS: SUMMARY

Table 11 summarizes the potential diversion of waterborne grain traffic to all-rail routings under the two closure scenarios and under three conditions: (1) the average observed flows between 1999 and 2017, (2) 2017 flow volumes, and (3) the maximum flows observed in Table 10. The percentage values indicate the percentage increase in originating tonnage within the five-state study area. These flows constitute the volumes that are carried forward in Sections 4 and 5 which consider terminal and line-haul rail capacities.

Table 11 – Closure Scenarios All-Rail Diversions

Conditions	LaGrange	Lock & Dam 25
Average Flows	0 (0.0%)	9,553,411 (2.2%)
2017 Flows	1,503,9945 (0.6%)	12,153,035 (2.8%)
Maximum Flows	15,358,665 (3.4%)	28,507,755 (6.7%)

Source: The University of Tennessee

Note: Maximum flows for LaGrange are calculated by taking maximum flows through LaGrange (17,858,665) less 2.5 million tons to East St Louis and 1 million tons of capacity below LaGrange. For maximum flows for Lock & Dam 25, it is assumed that zero tons can be diverted to the Illinois River and East St Louis and elevators below LaGrange lack additional capacity.

It is relatively certain that traffic diverted from the waterways would seek all-rail routings. Where this traffic would enter the railroad network and the locations for which it would be destined, and how it would affect other rail shipments across the U.S., are functions of railroad line-haul and rail-served terminal capacities.

4. DIVERSIONS, TERMINALS AND TERMINAL CAPACITY

Section 5 considers the line-haul impacts of placing several million additional tons of grain in narrow corridors on the nation's railroad network. However, before doing so, it would be necessary for shippers to change originating terminals and for the newly selected terminals to accommodate the additional tonnages. Likewise, if rail is envisioned as an alternative to barge transport in the movement of export grain, export terminals would need to accommodate in-bound shipments by rail rather than barge. These capacity issues are considered here.

4.1 STUDY REGION RAIL-SERVED TERMINALS

Table 12 summarizes the available rail-served grain terminals, both within the study region and in exporting states. Terminals are divided into three groupings, based on the number of rail cars that can be spotted at any point in time.[21] In Iowa, Illinois, and Minnesota, there are 80, 51, and 67 relatively large terminals that, based on car capacity, are at or close to the thresholds used to establish shuttle train service. This does not, however, guarantee that some combination of

[21] Terminal locations and characteristics are generally based on information provided by railroads. If a terminal is served by more than one railroad, the original data contained duplicate records. Every attempt was made to eliminate this duplication in the development of Table 12. Also, the tallies included in Table 12 primarily reflect Class I railroad-served facilities. However, in those instances where short-line carriers are an important source of grain transportation, they were also included. Finally, the three groupings are consistent with an analysis conducted by the Upper Great Planes Transportation Institute in 2012. See, Kimberly Vachal, "Regional Elevator Transportation: Market Decisions and Rail Service," Upper Great Plains Transportation Institute, North Dakota State University, November 2012.

these terminals would be capable of meeting the increased demands associated with the various disruption scenarios summarized above.

Table 12 – Rail-Served Grain Terminals

	1 - 24 Cars			25-69 Cars			70 or Greater Cars		
State	# of Facilities	Average Car Capacity	Average Storage Capacity	Number of Facilities	Average Car Capacity	Average Storage Capacity	Number of Facilities	Average Car Capacity	Average Storage Capacity
ORIGIN STATES									
Iowa	13	11	1,557,000	88	37	1,732,000	80	101	3,036,000
Illinois	34	14	1,336,000	62	37	3,310,000	51	114	4,878,000
Minnesota	22	14	909,000	68	37	1,614,000	67	105	3,117,000
Missouri	26	15	1,355,000	25	38	1,640,000	16	101	2,277,000
Wisconsin	3	12	1,200,000	17	28	3,752,000	4	106	2,190,000
DESTINATION STATES									
Alabama	4	12	205,000	3	50	430,000	3	111	2,000,000
Louisiana	-----	-----	-----	4	25	1,389,000	9	116	4,750,000
Oregon	6	12	928,000	4	34	1,071,000	4	107	5,370,000
Texas	38	14	1,062,000	53	40	2,415,000	33	119	6,007,000
Washington	15	13	1,308,000	33	28	1,319,000	17	141	3,161,000

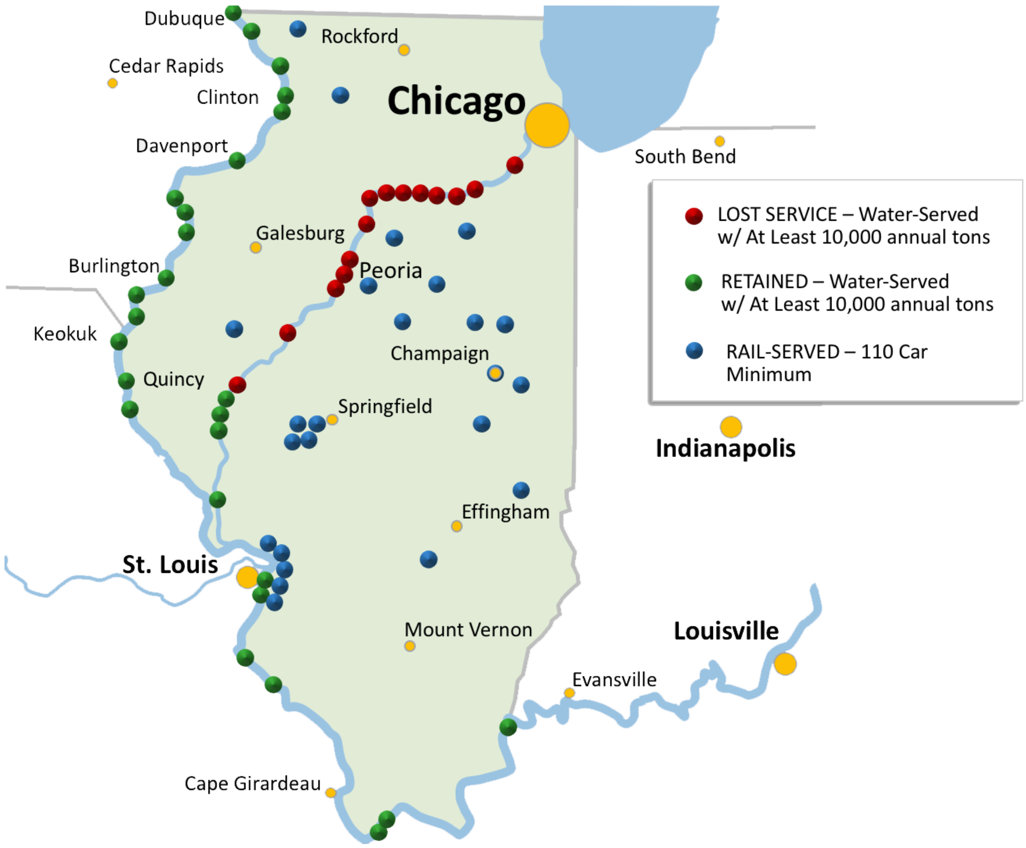
Source: The University of Tennessee

Illinois and LaGrange Outage

In an average year, the grain traffic displaced by an unplanned closure at LaGrange Lock & Dam could likely be handled by waterway terminals on the upper Mississippi. However, the two other LaGrange scenarios introduced above would result in an attempted diversion of up to 15.4 million tons of grain traffic to all-rail routings (Table 11). Assuming 110 car trains and 110 tons per carload, this additional demand would require roughly more than 25 additional trains per week over a 50-week year. On a daily basis, assuming six-day per week operations, rail served terminals would be required to acquire and store up to 51,000 tons of grain each day. Assuming that a large, efficient terminal can process 2,000 tons daily, the increased demand would require that the equivalent of up to 26 new terminals worth of capacity be gleaned from existing regional facilities.

Figure 8 depicts the region's waterborne grain terminals and rail terminals in Illinois that are capable of accommodating 110 cars at a time. It is easy to imagine that these terminals could accommodate an additional 2.5 million annual tons (all-rail diversions in 2017) by, in combination, loading an additional four trains per week. It is however, impossible to imagine that these terminals could accommodate an additional 14 million tons per year (maximum rail diversions) or load the 24 additional trains that would be required each week.

Figure 8 – Water-Served and Shuttle-Train-Capable Illinois Grain Terminals



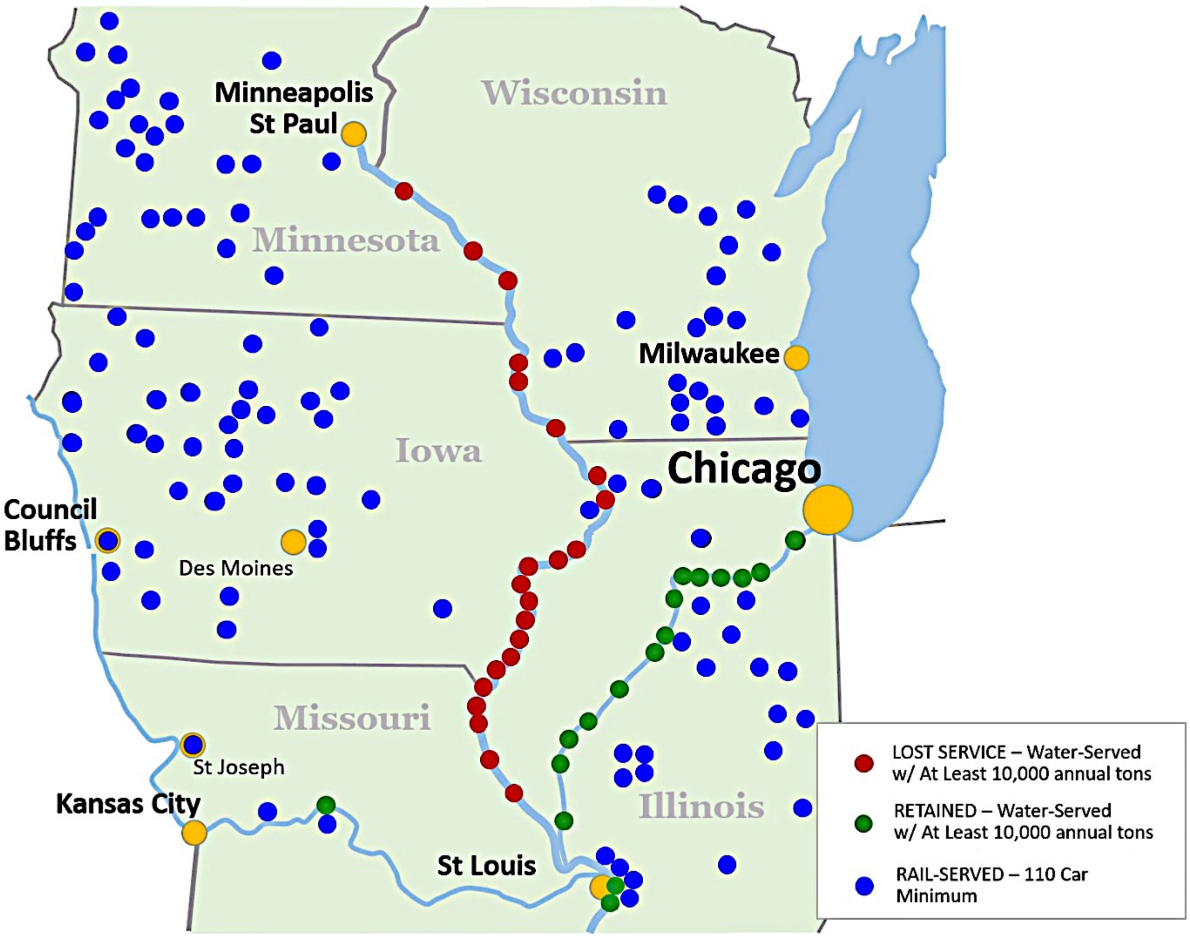
Source: The University of Tennessee

To summarize, in an average year, an unplanned outage at LaGrange would require no additional rail-served grain terminal capacity. Moreover, even in a relatively busy year like 2017, Illinois's rail-served terminals could accommodate the additional traffic. However, in a worst-case scenario, where there is no incremental capacity at water-served terminals along the Mississippi, Illinois rail-served terminals could not accommodate nearly all the displaced grain traffic.

Lock & Dam 25 Outage

An unplanned outage at Lock & Dam 25 would have the potential to affect grain shippers in all five study region states. However, the effects would likely be most pronounced in Iowa and Minnesota. Missouri shippers would have the option of trucking to the Illinois River or to the Mississippi terminals at Cahokia and East St Louis; Illinois shippers could easily transition to the Illinois River, relying on excess capacity there, and Wisconsin's modest volumes could likely find alternative markets over the Great Lakes ports of Superior and Duluth. Figure 9 depicts the locations of barge-served facilities (both available and unavailable for Gulf-bound shipments), as well as the locations of 110-car-capable, rail-served terminals.

Figure 9 – Water-Served and Shuttle-Train-Capable Study Region Grain Terminals



Source: The University of Tennessee

With the upper Mississippi closed to Gulf-bound shipments and Illinois River terminal capacity absorbed by diverted Illinois traffic, a tremendous amount of grain grown in eastern Iowa and southeastern Minnesota would be forced toward all-rail routings. Again, referring to the scenarios summarized in Table 11, the volume of displaced grain traffic would equal 9.5 million tons in an average year, 12.2 million tons in a somewhat busier year like 2017, or 28.5 million tons in the worst possible case where no Illinois River (or St Louis) capacity is available.

While there are many 110-car, rail-served facilities in both Iowa and Minnesota, the influence of the Mississippi River and the prominence of local processing have left eastern Iowa and southeastern Minnesota relatively devoid of such facilities. A handful of shuttle-train-capable locations are available in southwestern Wisconsin, but setting these aside, Wisconsin offers very little shuttle-train capacity.

Using the same parameters applied to the LaGrange Outage, a closure at Lock & Dam 25 would require between 16 and 47 additional trains each week to accommodate the grain diverted from the upper Mississippi. This would entail collecting and processing between 32 and 95 thousand tons of grain by terminals that do not currently handle these quantities. In 2016, Iowa and Minnesota originated 30.6 million tons of grain by rail. Meeting the closure requirements would require a 31 to 93 percent increase in throughput over rail-served terminals. As with the case of the LaGrange closure, meeting the minimum scenario target might be manageable, but meeting the maximum potential diversion of waterway traffic probably is not.

The Lock and Dam 25 closure scenario produces one outcome that differs from the LaGrange scenario. In the latter case, diverting waterway movements to all-rail routings would not significantly increase trucking distances over the distances typically incurred to reach the river. However, given the geographic distribution of 110-car-capable elevators, a Lock & Dam 25 closure would likely increase truck distances for diverted traffic.

In Illinois, grain typically travels 40-50 miles to reach a river terminal and shipments up to 100 miles are not uncommon. The geography suggests that, in Iowa and Minnesota, typical distances to the waterway may be somewhat longer, with an average of 50-70 miles and a typical outer limit of, perhaps, 110 miles. Reaching areas with necessary rail-served capacity may involve measurably longer distances for shippers wishing to divert displaced barge traffic to all-rail routings. Representative city pairs and highway distances are provided in Table 13.

Table 13 – Representative Distances to All-Rail Terminals

Origin	Destination	Highway Miles
McGregor, IA	Mason City, IA	122
Cedar Rapids, IA	Council Bluffs, IA	254
Winona, MN	Kiester, MN	185
Clinton, IA	Cedar Rapids, IA	83
Mount Pleasant, IA	Creston, IA	155
Iowa City, IA	Des Moines, IA	115
Grinnell, IA	Atlantic, IA	135
Red Wing, MN	St James, MN	163

Source: The University of Tennessee

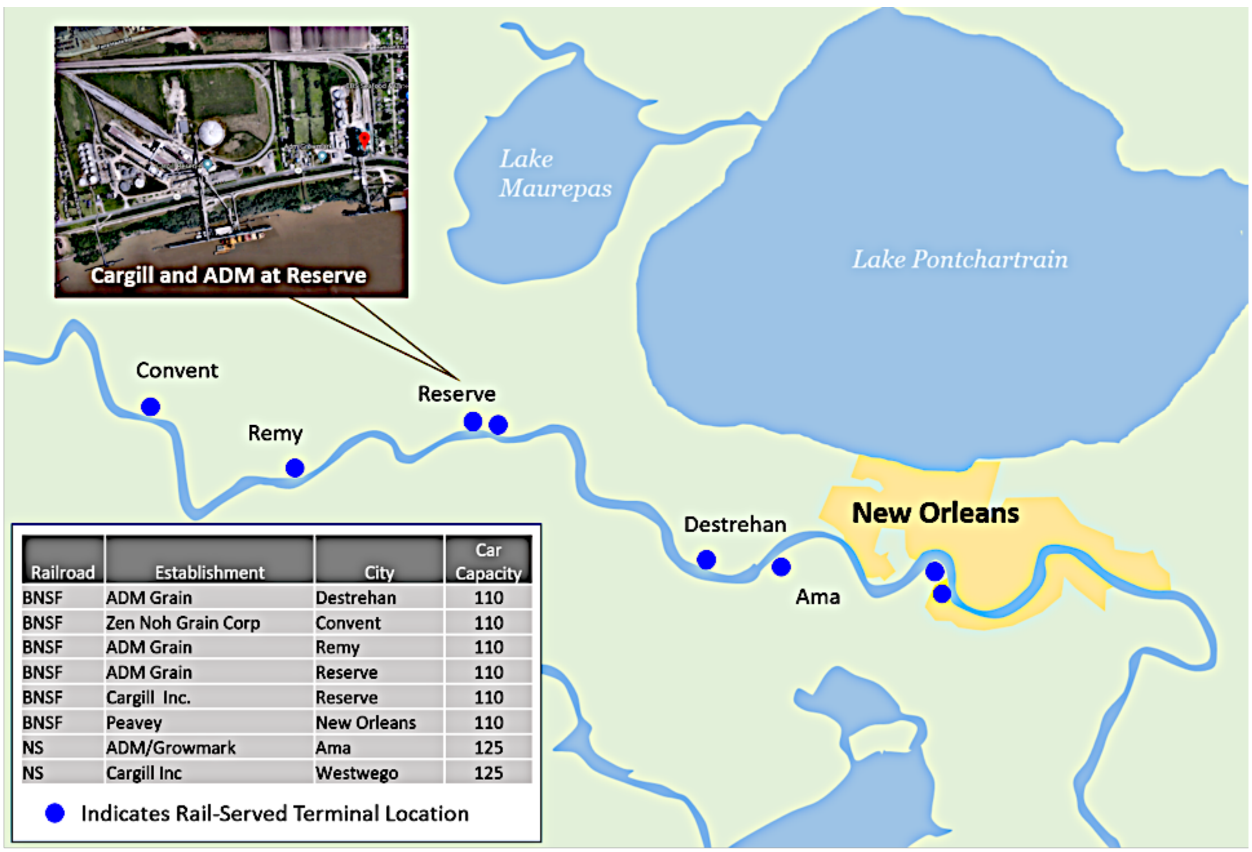
4.2 EXPORT TERMINALS: THE LOUISIANA GULF

The grain traffic that would be displaced by an unplanned closure at LaGrange or at Lock & Dam 25 is almost exclusively destined for export over the Louisiana Gulf, so that it would seem desirable to ship the same quantities of grain to the same export locations. However, there is a complicating element. At least some of the busiest export terminals are not terminals at all, but are instead mooring locations for the midstream transfer of grain. In this light, the question of terminal capacity is less easily brushed aside.

The closure scenarios summarized in Table 11 indicate a potential diversion from barge to rail of up to 28.5 million tons, with the most likely values ranging between 9.6 and 15.3 million tons. Here we proceed with the simple average of these two values, 11.9 million tons. Figure 10 depicts the locations of the rail-served, New Orleans area grain terminals.

Each of these facilities includes high-capacity rail car storage and unloading capabilities that appear to be little used. The majority feature large loop tracks, but the terminals that rely on ladder track storage have to be well-designed with long storage tracks that can be accessed from both ends.

Figure 10 – New Orleans Area, Rail-Served Grain Terminals



Railroad	Establishment	City	Car Capacity
BNSF	ADM Grain	Destrehan	110
BNSF	Zen Noh Grain Corp	Convent	110
BNSF	ADM Grain	Remy	110
BNSF	ADM Grain	Reserve	110
BNSF	Cargill Inc.	Reserve	110
BNSF	Peavey	New Orleans	110
NS	ADM/Growmark	Ama	125
NS	Cargill Inc	Westwego	125

Source: The University of Tennessee

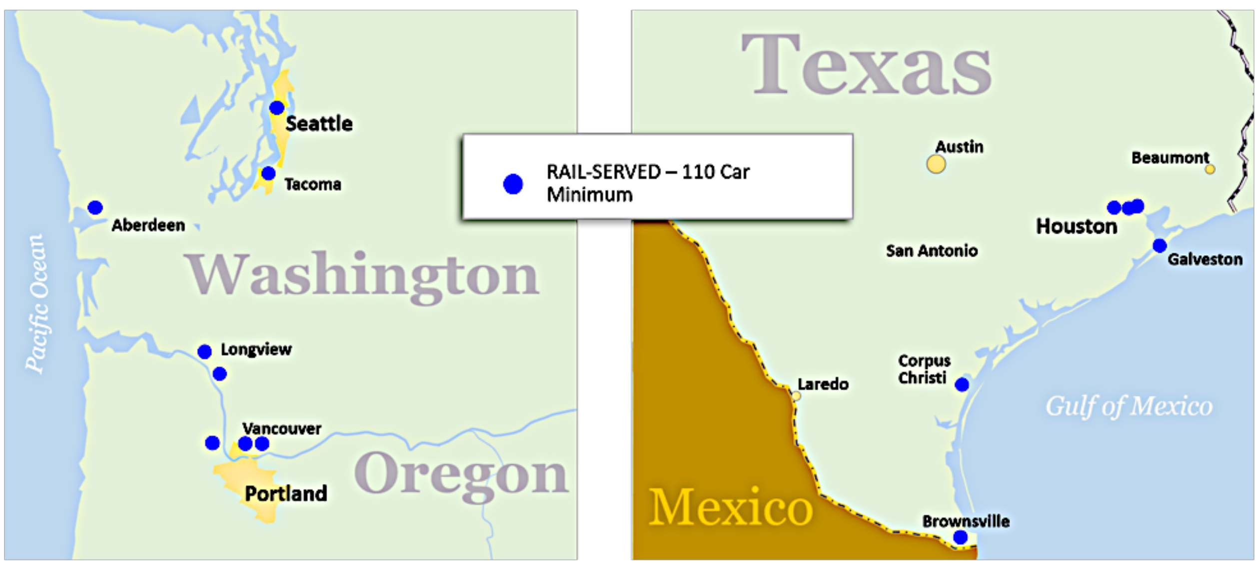
As before, we assume 110 car trains with lading weights of 110 tons per car. If the whole of the current rail volumes to the Louisiana Gulf (roughly 3.8 million tons) passed through these eight terminals, each would need to unload a little more than one train every two weeks. To accommodate the average likely barge-to-rail diversion of 11.9 million tons would require an additional 19.7 trains per week, so that, in total, each of the rail-served terminals would need to unload three trains per week. Although this would represent a six-fold increase in throughput, it does not seem unreasonable, given the nature of the rail-served facilities.

However, as with the origin terminal capacity, the worst-case scenario of 28.5 million diverted tons would place demands on the rail-served terminals that could likely not be met, at least on an ongoing basis. To meet this level of demand each terminal would need to increase rail throughput by six trains per week.

4.3 EXPORT TERMINALS: TEXAS AND THE PACIFIC NORTHWEST

If the only concern is export terminal capacity, it is the study team's judgment that, under most scenarios, it would be possible to continue routing traditional volumes of upper basin grain to Louisiana Gulf export locations. However, in the event the Louisiana terminal capacity is insufficient, it would be possible to route some residual volumes to other areas, such as Texas ports or through the Pacific Northwest (PNW). Figure 11 combines depictions of the 110-car-capable terminal facilities in both regions. In Texas, export facilities are concentrated in the Houston-Galveston area. In the PNW, there are multiple facilities at (and near) Vancouver Washington, near Longview Washington, and in the Seattle-Tacoma area. A further description of the export grain facilities in both regions is provided in Table 14.

Figure 11 – Shuttle Train-Capable Terminals in Texas and the Pacific Northwest



Source: The University of Tennessee

Table 14 – Shuttle Train-Capable Terminals in Texas and the Pacific Northwest

Serving Railroad	Terminal	City	State	Storage	Car Capacity
BNSF	Temco Llc	Albina	OR	1,400,000	54
BNSF	Columbia Export Terminal LLC	Rivergate	OR	4,000,000	130
BNSF	AGP International Terminal 2	Aberdeen	WA		110
BNSF	Seattle Bulk Shipping Inc.	Harris Island	WA		74
BNSF	Louis Dreyfus Company	Interbay	WA	4,200,000	160
BNSF	Kalama Export Company LLC	Kalama	WA	3,500,000	112
BNSF	Port of Longview	Longview	WA		110
BNSF	EGT LLC	Longview	WA		440
BNSF	Highline Grain Growers, Inc.	Marlin	WA	205,000	26
BNSF	Tri-Pak Four	Tacoma	WA		15
BNSF	Temco LLC	Tacoma	WA	3,000,000	250
UP/BNSF	United Grain	Vancouver	WA	5,000,000	110
BNSF	Great Western Malting Co	Vancouver	WA	5,000,000	15
BNSF	ADM Grain	Corpus Christi	TX	5,200,000	115
BNSF	Interstate Grain	Corpus Christi	TX	6,500,000	120
BNSF	ADM Grain	Galveston	TX	3,200,000	120
BNSF	Hansen Mueller Co	Houston	TX	6,200,000	80
BNSF	Louis Dreyfus Company	Houston	TX	6,000,000	250
BNSF	Cargill Inc	Houston	TX	6,000,000	280
BNSF	West Plains LLC	Brownsville	TX	3,000,000	110

Source: The University of Tennessee

5. LINE-HAUL RAILROAD CAPACITY

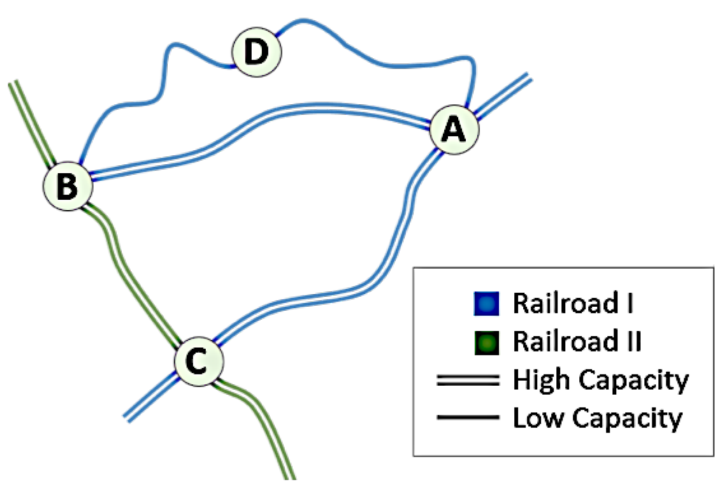
Section 4 suggests that, under some circumstances, the grain terminal infrastructure at both ends of the upper basin-to-Louisiana corridor could accommodate the rail-to-barge traffic diversions resulting from an unscheduled outage at LaGrange or Lock & Dam 25. The additional costs owing to this accommodation are discussed in Section 6. Here, however, we consider whether the railroad network that would be called upon to provide the additional line-haul transportation would be able to do so without disrupting existing traffic flows. This work is divided in to two parts. In Sections 5.1 – 5.5, the analysis considers the adequacy of line-haul railroad infrastructure. Crew and equipment issues are treated in Section 5.6.

5.1 THE *RAILNET* SIMULATION PLATFORM

To identify the effects of introducing up to 28.5 million tons of additional grain traffic onto the U.S. railroad infrastructure, we use an analytical platform developed at the University of Tennessee informally known as *RAILNET*. The *RAILNET* framework is a GIS-based set of computational programs that place railroad traffic on the rail network based on routes that provide the required transportation *and* minimize system transportation costs, thereby providing routes and corresponding traffic volumes that are more realistic than algorithms that simply minimize transit distances or times. Figure 12 provides an example.

Consider traffic flows between A and B. Three routes can host this flow: the high-capacity route on Railroad (RR) I that directly connects A and B, the low-capacity route through D on RR I that connects A and B, and a final route that includes movement along the high-capacity RR I link from A to C, interchange at C, and movement on RR II's high-capacity route from C to B. The simplest routing models would place all AB flows on RR I's high capacity route between the two nodes. A slightly more complex routing model might divide the westerly AB flow between RR I's high capacity and low capacity routes based on some relative capacity measure.

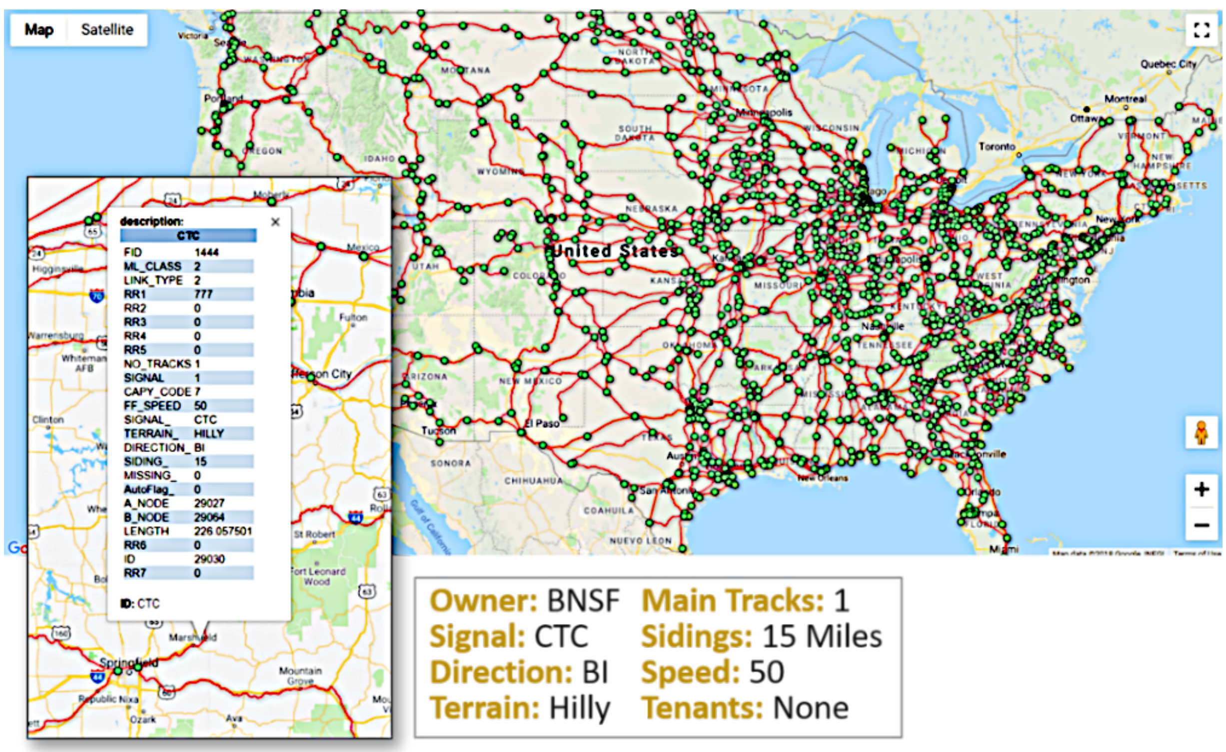
Figure 12 – The *RAILNET* Framework: An Example



The *RAILNET* approach is both more comprehensive and realistic. The network pictured in Figure 12 supports 12 directionally-specific flows that can be achieved through 36 distinct routings.[22] *RAILNET* simultaneously considers the demand for each traffic flow, the capacity characteristics of the route links, and the value of each commodity to determine the lowest total cost of accommodating *all* network demands. Thus, returning to our example, the AB flow is allocated to a combination of the three routing alternatives, based on the capacity of the network components and the totality of the traffic throughout the network. Moreover, if there is a change to *any* network component or *any* of the network flows, those changes can (potentially) affect the way that the AB flows are allocated. It is this responsiveness that makes *RAILNET* particularly useful in executing simulations.

RAILNET requires a GIS network that is more heavily attributed than what is typically available, and it requires carefully developed information describing carrier costs.[23] The *RAILNET* network, along with a sample of link attributes is pictured here as Figure 13.

Figure 13 – The *RAILNET* Network and Attributes



Source: The University of Tennessee

[22] Specific directional OD pairs include AB, AC, AD, BA, BC, BD, CA, CB, CD, DA, CB, and CD. Moreover, each OD pair can be connected by three distinct routings. For example, the AB route may direct A to B. Alternatively, A to B shipments could be routed via ADB or ACB.

[23] For a full description of RAILNET see, "An Economic Analysis of the Appalachian Coal Industry Ecosystem: Transportation Implications of Coal, Appalachian Region Commission, January 2018, Appendix C, available at: https://www.arc.gov/assets/research_reports/CIE3-TransportationImplicationsofCoal.pdf.

The present application begins with the whole of U.S. rail traffic as captured by the 2015 Carload Waybill Sample (CWS). Individual waybill records are expanded then aggregated by originating railroad, originating county, terminating county, and commodity groups. For the purpose of this analysis, commodity groups are based on the definitions outlined in Table 15. Summary statistics based on these groupings are provided in Table 16. The *RAILNET* routings, link-specific traffic volumes, transit times, and estimated costs estimated in this initial execution form the baseline conditions against which later scenario runs are evaluated. Baseline flows (measured in annual gross tons) are depicted in Figure 14. While *RAILNET* traffic assignments may sometimes vary from observed practice, aggregated results are encouraging. *RAILNET* routings produced a total of 2.995 million railroad ton-miles. Actual ton-miles reported by the STB for the same time period were 3.198 million, a difference of less than eight percent.

Table 15 – *RAILNET* Commodity Groupings

	RAILNET Commodity Group	Standard Transportation Commodity Codes
Other Farm Products	1	01 Excl. 1132, 1137, 1144
Corn	2	1132
Wheat	3	1137
Soybeans	4	1144
Coal	5	11
Bulk Commodities	6	10, 14, 29, 32, 40
Processed Goods	7	20, 24, 26, 33, 34
Non-Liquid Chemicals	8	28
Tank Car Traffic	9	Based on AAR Car Type
Automobiles and Parts	10	371
Intermodal	11	42, 44, 45, 46
Other	12	All Other Records

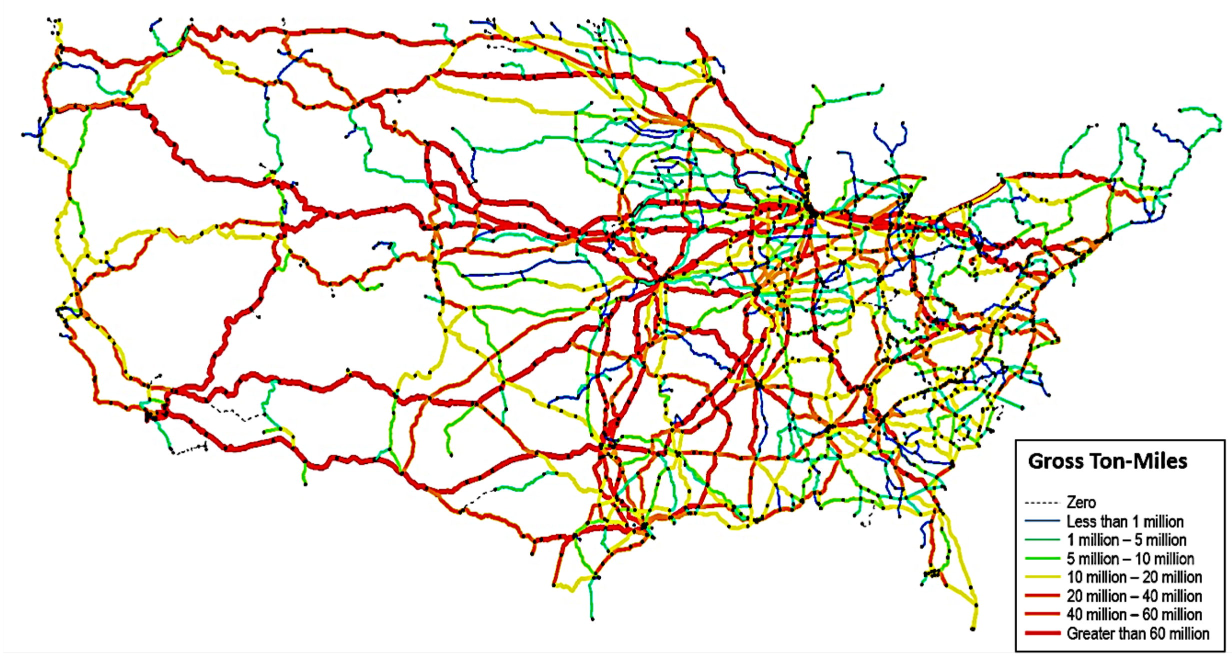
Source: The University of Tennessee

Table 16 – CWS Summary Statistics by *RAILNET* Commodity Group

	RNCG	N	Total Number of Carloads	Total Number of Tons	Mean Trip Distance	Mean Tons per Car	Mean Number of Carriers
Other Farm Products	1	9,002	447,565	24,127,626	1,334	78.4	1.2
Corn	2	4,242	677,801	71,261,669	1,105	107.0	1.2
Wheat	3	3,270	358,767	37,275,230	969	105.3	1.2
Soybeans	4	1,798	278,611	28,579,400	1,156	105.5	1.4
Coal	5	24,694	6,140,585	721,439,314	810	117.8	1.1
Bulk Commodities	6	44,987	3,679,926	331,841,705	475	101.2	1.2
Processed Goods	7	90,380	3,902,658	245,179,743	1,117	84.7	1.4
Non-Liquid Chemicals	8	36,474	1,636,335	124,091,900	949	94.6	1.4
Tank Car Traffic	9	59,339	3,190,053	281,114,476	1,059	92.3	1.4
Automobiles and Parts	10	56,529	2,261,880	44,772,242	1,026	23.0	1.1
Intermodal	11	291,384	11,655,620	140,728,000	1,463	15.9	1.1
Other	12	44,307	1,854,626	26,154,175	1,305	26.9	1.2

Source: Carload Waybill Sample

Figure 14 – Baseline Railroad Traffic Flows



Source: The University of Tennessee

5.2 MODEL VALIDATION AND RAIL CARRIER BEHAVIOR

While the initial baseline simulations produced an aggregate 2015 ton-mile value that was very close to the figure reported by the rail industry, carrier-specific ton-miles were less reliable. Moreover, an examination of routings indicated an amount of traffic interchange between railroads that was *significantly* greater than what is observed in day-to-day railroad operations. *RAILNET* is designed to minimize the cost of moving system-wide traffic, without regard to the financial implications for individual carriers. Consequently, the optimization produced routings that were technically efficient from a system vantage, but which often were inconsistent with the profit-maximizing behaviors of originating carriers.[24]

RAILNET relies on several carrier-specific cost parameters within the optimization process. One of these parameters measures the cost of interchanging traffic with other railroads. All cost parameters are based on cost data collected annually by the Surface Transportation Board and were derived, as well as possible, to reflect the actual incremental cost of specific movement activities. However, the use of actual interchange costs failed to reflect railroads' financially-based aversion to interchanging traffic with connecting carriers when doing so is avoidable.

[24] Technically, shippers have the legal ability to specify freight routings, but most shippers neither know nor care how shipments are routed. Therefore, routing decisions are routinely left to the originating railroad. If the originating carrier serves both the origin and destination locations, it will choose to be the lone participant in the move, almost without regard to distance. Moreover, even when interchange must occur to reach the shipment's destination, the originating carrier will attempt to maximize its share of the overall shipment distance.

To remedy the situation, the study team adopted two parallel analytical alternatives. The first of these is referred to as the *unconstrained* case wherein *RAILNET* is allowed to seek the least-cost routings and assign traffic without attention to individual carrier outcomes. Under the second (*constrained*) course, routes that involve efficient, but unnecessary, interchange are penalized by artificially inflating the interchange cost parameter. Interestingly, imposing this constraint did not reduce overall efficiency by a large amount. On average, the constraint increases aggregate ton-miles by 2.1 percent and aggregate line-haul train delays by 6.6 percent.

A full range of simulations were executed under both analytical alternatives and, in every case the *constrained* alternative provided more robust results. That is, the number of interchanges better reflects actual railroad practices and, though certainly not perfect, the distribution of total ton-miles among Class I carriers is more realistic under the *constrained* case. Because the *constrained* simulations consistently provide better results, it is those results that are reported here. However, where it is instructive, to do so, the *unconstrained* results are provided for comparison.[25]

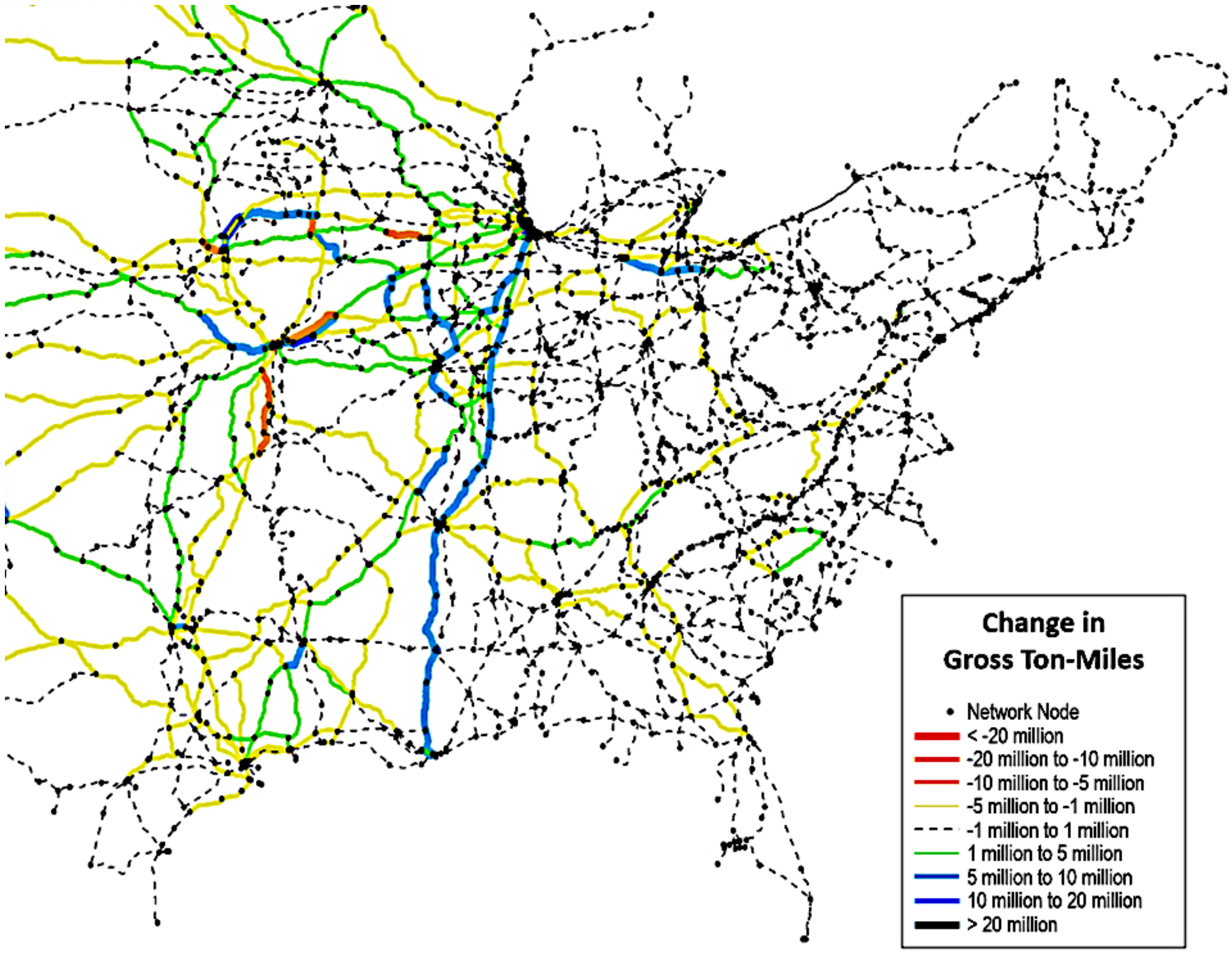
5.3 SCENARIO 1: LAGRANGE DISRUPTION TRAFFIC

The information developed in Section 3 suggests an unplanned closure at LaGrange Lock & Dam in an average year would not necessitate a diversion of waterway traffic to rail. In contrast, an outage during the most extreme year would require that approximately 13.4 million tons of grain traffic be diverted to the rail network (Table 11). Based on the midpoint of these values, to simulate the network effects of an unscheduled closure, seven million tons of additional corn and soybeans were added to Illinois origins and routed to the Louisiana Gulf. The changes attributable to the additional rail traffic are depicted in Figure 15 and summarized in Table 17.

A key advantage of the *RAILNET* platform is that it fully captures network effects, but this also means that Figure 15 and Table 17 exhibit network effects that beg for explanation. The net change in gross ton-miles and related percentage change are across each Class I system. The percentage change in delay describes the change in line-haul delay times for affected links. Links where delay times were unaffected are not included in this calculation.[26]

Figure 15 – Changes to Baseline Rail Flows under Scenario 1

[25] A full set of results for the *unconstrained* case is available from the study author upon request.
[26] Delay is calculated in hours per train across each link. In calculating averages, delay times are weighted by the link length.



Source: The University of Tennessee

Table 17 – Changes to Baseline Rail Flows Under Scenario 1

Railroad	Net Change, Gross Ton-Miles	Percent Change, Ton-Miles	Percent Change, Delay	Network Links with 25% or More Volume Change	Network Miles with 25% or More Volume Change
BNSF	-140,000,000	-0.01%	0.57%	4	179
Union Pacific	4,700,000,000	0.44%	2.84%	28	650
Kansas City Southern	106,804,480	0.43%	2.68%	4	51
Norfolk Southern	3,137,482,639	0.97%	1.57%	15	472
CSX	599,082,788	0.18%	2.75%	10	242
Canadian National	7,191,720,899	6.70%	3.58%	19	527
Canadian Pacific	-119,991,865	-0.37%	-2.99%	1	1

Based on the *RAILNET* simulation, most of the diverted traffic would move between Illinois and the Louisiana Gulf via the Canadian National from Memphis southward, with the balance of diverted traffic moving over the Union Pacific in a more circuitous routing.[27] Even though the subject grain traffic would be concentrated on these carriers, the diversion of waterway traffic to all rail-routings would require a significant redistribution of existing rail traffic among nearly all of the region's Class I and many of its short-line railroads. In fact, as Section 5.3 and 5.4 show, even though the diverted tonnage in Scenario 1 is the smallest of the three scenarios, it seems that this scenario produces the most volatile results. Without any ability to confirm our hypothesis, we expect that this outcome is tied to the proximity of the diverted traffic to Chicago which serves as the nation's busiest interior rail interchange location.

It is also important to understand that *RAILNET* points to the least-cost way of accommodating the diverted traffic, but this does not guarantee that the region's Class I railroad could or would adhere to this prescription. The need to redistribute existing traffic highlights an interesting economic issue. There is no central authority directing railroad traffic flows; these flows are dictated by market outcomes. Therefore, for this redirection of traffic to occur, the relative rates offered by the affected railroads would need to change in order to produce the predicted outcomes. In a simulation setting, the necessary changes in traffic flows occur instantaneously. But in reality, the market mechanics necessary to yield the same flow changes could be both slow and sloppy, particularly given the extensive use of contracts in rail carriage. Once again, this suggest that inflexibility may be a potential issue.

Finally, even if railroads and the markets in which they sell services responded as predicted to the infusion of additional grain traffic, the result would be traffic volume increases of more

[27] *RAILNET* does not force delivery by a terminating railroad. Therefore, even though BNSF is the dominant carrier serving Louisiana Gulf grain terminals, its participation on the Gulf end of the diverted movements is not indicated in either Figure 15 or Table 17.

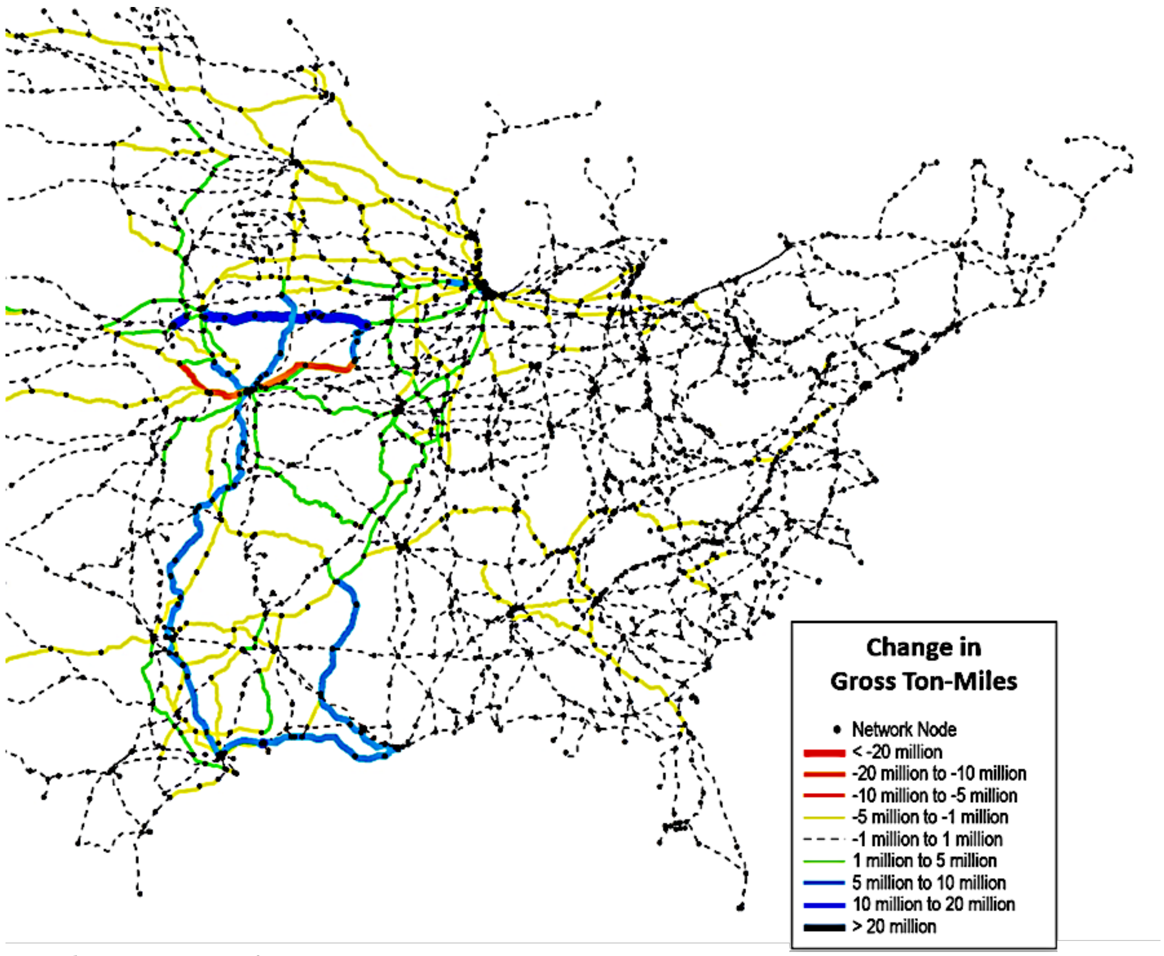
than 25 percent over more than 2,000 miles of the Midwest's railroad network. As Table 17 indicates, the increased traffic would lead corresponding increases in line-haul train delays.

5.4 SCENARIO 2: LOCK & DAM 25 DISRUPTION TRAFFIC

As described above, an unplanned closure at Lock & Dam 25 on the upper Mississippi River would divert waterway traffic to rail under every scenario. In the extreme diverted grain tonnage could foreseeably reach as much as 28.5 million tons. However, most outcomes point to traffic diversions of between 9.6 and 15.3 million annual tons.

To capture the railroad network effects of this additional tonnage, 11.6 million tons (again, the midpoint of the two values) of additional grain traffic were added to the annual traffic between the upper basin and the Louisiana Gulf. These additional flows would originate at dozens of locations across central and western Iowa and Minnesota. However, determining precise origins and associated quantities is beyond the scope of our work. Moreover, given the nature of the gathering networks, much of this incremental traffic would funnel through Council Bluffs/Omaha or Des Moines. Therefore, to create a corresponding *RAILNET* simulation, the 11.6 million tons were divided equally, then added at Council Bluffs and Des Moines. The results of the Scenario 2 simulations are depicted in Figure 16 and reported in Table 18.

Figure 16 – Changes to Baseline Rail Flows Under Scenario 2



Source: The University of Tennessee

Table 18 – Results of Scenario 2 Additions to Rail Traffic

Railroad	Net Change, Gross Ton-Miles	Percent Change, Ton-Miles	Percent Change, Delay	Network Links with 25% or More Volume Change	Network Miles with 25% or More Volume Change
BNSF	16,300,000,000	1.54%	0.09%	26	881
Union Pacific	6,500,000,000	0.61%	2.27%	18	596
Kansas City Southern	207,736,145	0.84%	2.68%	0	0
Norfolk Southern	276,105,802	0.09%	0.34%	4	102
CSX	-55,044,788	-0.02%	0.34%	8	151
Canadian National	-303,160,565	-0.28%	-0.98%	2	41
Canadian Pacific	-84,483,623	-0.26%	-3.16%	0	0

Source: The University of Tennessee

Of the three scenarios, the Scenario 2 results are the least disruptive and most plausible. The Council Bluffs traffic primarily originates on BNSF and remains on that carrier, passing through Kansas City, Tulsa, Fort Worth, and Houston, before heading east to New Orleans. The Des Moines traffic either moves west to join the Council Bluffs traffic or east toward Chicago, where it is moved to the Gulf via the Union Pacific.[28]

The east-west portion of BNSF that spans Iowa and which would see the largest increase in traffic is largely double-track railroad and both the BNSF and UP routes between Council Bluffs/Chicago and the Gulf are comprised of solid, if not speedy, single-track routes that are controlled by Centralized Traffic Control (CTC).

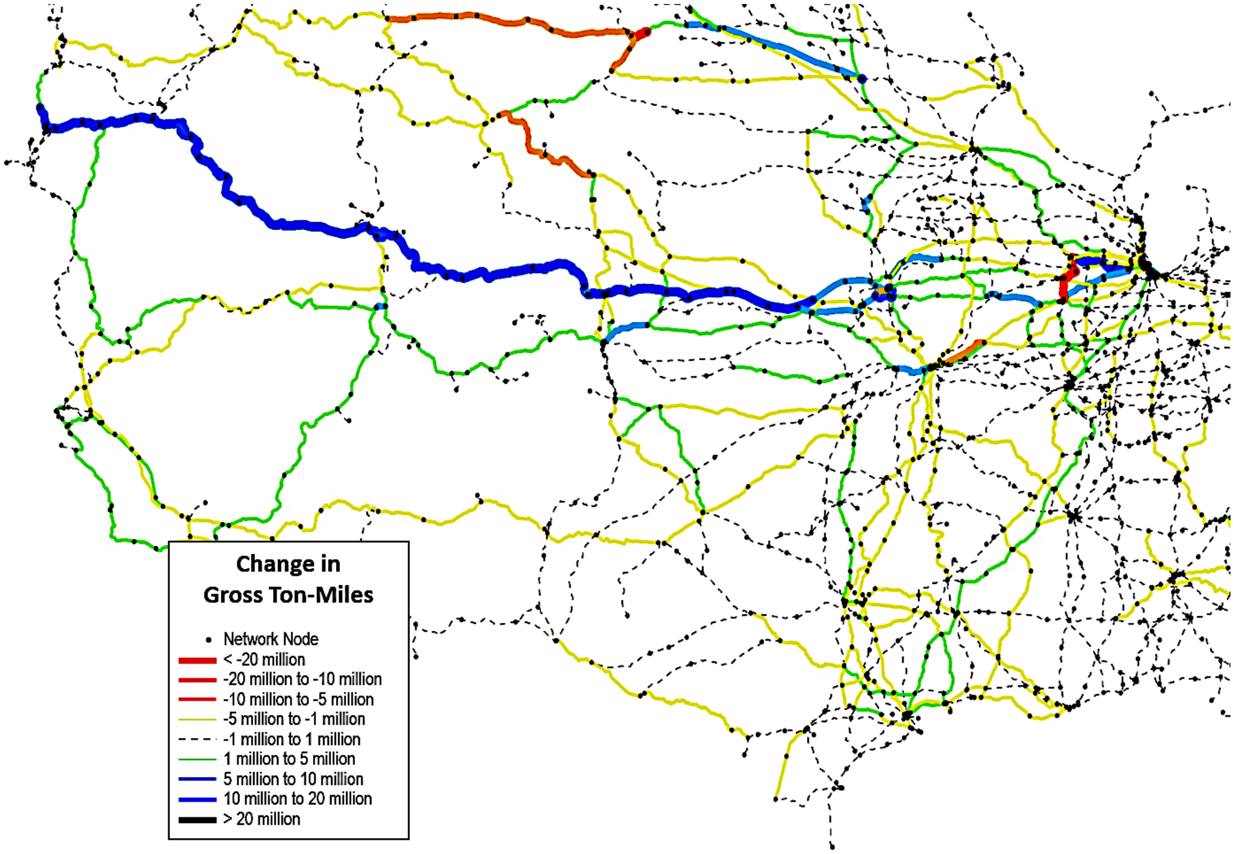
5.5 SCENARIO 3: LOCK & DAM 25 DISRUPTION TRAFFIC (PNW)

Section 4 notes that, if the capacity at rail-served terminals in the Louisiana Gulf is insufficient to accommodate the entirety of diverted rail traffic, it should be possible to redirect some of the export grain to the PNW. The same is true in the case of railroad line-haul capacity. There is nothing in scenarios 1 and 2 that would definitively indicate this further diversion of export traffic. Nonetheless, the extensive reallocation of traffic pointed to in the execution of Scenario 1 suggests that exploring capacity under a PNW alternative is prudent. In this light, Scenario 3 redirects Scenario 2 traffic (11.6 million tons of corn and soybeans) to an alternative export location in the PNW, near Vancouver, Washington.[29] The results of the *RAILNET* simulations are provided in Figure 17 and Table 19.

[28] Readers will observe that a portion of the Council Bluffs traffic is diverted away from BNSF at Kansas City and routed to the UP via the Missouri & North Arkansas (M&NA), a Class III short-line. Somewhat ironically, the M&NA is comprised of former Missouri Pacific (MP) trackage that the Union Pacific disposed of after absorbing the MP.

[29] Vancouver, Washington and a variety of other locations in Clark County are the terminals that are routinely associated with Portland, Oregon.

Figure 17 - Results of Scenario 3 Additions to Rail Traffic



Source: The University of Tennessee

Table 19 – Results of Scenario 3 Additions to Rail Traffic

Railroad	Net Change, Gross Ton-Miles	Percent Change, Ton-Miles	Percent Change, Delay	Network Links with 25% or More Volume Change	Network Miles with 25% or More Volume Change
BNSF	7,200,000,000	0.68%	2.9%	43	1,468
Union Pacific	35,000,000,000	3.26%	4.4%	33	756
Kansas City Southern	89,510,301	0.36%	1.9%	0	0
Norfolk Southern	1,615,553,964	0.50%	0.3%	5	72
CSX	166,063,381	0.05%	0.2%	2	23
Canadian National	157,001,576	0.15%	-0.5%	7	196
Canadian Pacific	-19,992,306	-0.06%	1.5%	0	0

Source: The University of Tennessee

Even though the subject traffic originates on BNSF, *RAILNET* almost immediately moves it to the Union Pacific. This is because an all-BNSF routing would put the additional grain traffic in direct conflict with BNSF coal traffic. The Union Pacific route links through the Plains states, the Rockies, and the Pacific Northwest seeming to have the capacity to best accommodate the west-bound grain, but adding the incremental traffic to the existing traffic mix adds considerably to train delays.

5.6 BEYOND LINE-HAUL INFRASTRUCTURE

The results indicate, if a wide range of system network flows can be assigned across routes not routinely used, the network can accommodate the scenario flows. However, operating trains also requires locomotives, freight cars, train crews, and on-line terminal facilities. Table 20 combines parameter estimates used throughout our analysis to estimate the amount of equipment and number of crewpersons needed to accommodate the additional scenario tonnages. These totals do not include the incremental crew and equipment needed to accommodate scenario-induced train delays in the movement of non-scenario traffic. They also do not consider the extent to which the additional traffic may affect the cycle times for the rail cars used to transport grain.

Freight traffic in general is cyclical and this is truer of traffic volumes for specific commodity groups. Therefore, during average business conditions, there have historically been idle locomotives and furloughed train crews that could be restored to service if conditions change. During peak times, however, these surplus crews and locomotives quickly disappear. Similarly, at any point in time, there are tens of thousands of freight cars stored throughout the United States, but which particular car types are in storage depends on the specific demands for the movement of the commodities that require those cars. Moreover, in an era that favors Precision Scheduled Railroading, surplus equipment is likely to be scarcer.

Under typical circumstances, the equipment demands depicted in Table 20 would not impose a significant hardship on the nation's rail carriers. To the contrary, it is likely that equipment could be repositioned to meet outage-related increases in demands within 30 days, but this outcome is not guaranteed.

Train crews might be more problematic. First, it is exceedingly unlikely that furloughed crewpersons live at the locations where additional train crews would be needed. Thus, it would be necessary to induce their relocation or to attract and train new workers. Moreover, even if displaced crewpersons could be motivated to relocate, train crews must qualify to operate over specific geographic territories. When confronted with these scenarios, industry experts suggest it might take as long as six months to meet the scenario-related labor needs.

Table 20 – Additional Crew and Equipment Requirements

	SCENARIO 1 Peoria to New Orleans	SCENARIO 2 Council Bluffs to New Orleans	SCENARIO 3 Council Bluffs to Portland
Scenario Tons	7,000,000	11,600,000	11,600,000
Lading per Car	110	110	110
Train Length (Cars)	110	110	110
Trip Distance (One-Way)	1,016	1,231	1,996
Line-Haul Train Speed	25	25	25
Total Trip Days (Round-Trip)	8.4	9.1	17.7
Locomotives Needed	40	73	141
Freight Cars Needed	1,779	3,200	6,205
Crew Members Needed (FTEs)	68	137	222

6. REVIEWING DIVERSIONS AND ASSESSING DIVERSION COSTS

An unscheduled closure at either LaGrange or at Lock & Dam 25 would impose myriad costs on a wide array of entities, some of whom are directly tied to the production and transportation of grain and some of whom are not. Fully cataloguing and precisely calculating the magnitude of these costs is beyond the scope of the work reported here. Nonetheless, it is useful to calculate those incremental costs that are easily addressed. If nothing else, doing so provides a glimpse at the order of magnitude that might be observed under a more comprehensive cost review.

At some point after it is harvested, nearly every bushel of grain is moved by truck. Typically, because of the line-haul savings, farmers or smaller elevators are willing to truck longer distances to water-served terminals than they are to reach rail-served terminals. In the examples provided in Table 9, the average truck distance to a barge-served facility was assumed to be 40 miles and the average distance to available rail was assumed to be 20 miles.

However, when the status quo is disrupted, the associated trucking distances change. In the case of a LaGrange outage, nearly all diverted Illinois River traffic would, at first be trucked longer distances so that it could gain access to barge transportation on the Mississippi River. However, as Mississippi River terminal capacity is exhausted, the displaced Illinois would divert to all-rail routings that are available at Illinois terminals. As that happens, trucking distances and costs would return to levels at (or potentially below) their original levels.

An outage at Lock & Dam 25 would induce similar behaviors in that shippers would seek water-served alternatives on the Illinois River or on the Mississippi at or below St Louis. However, unlike the LaGrange case, the 110-car-capable, rail-served alternatives that would receive varying portions of the diverted Mississippi River traffic are at long distances from where the grain is grown. Consequently, whether diverting to an alternative water-served location or to an all-rail routing, all Lock & Dam 25 traffic would face higher trucking costs. The assumption here is that these truck legs could average 150 miles.

Without the information needed to do otherwise, our analysis assumes that trucking rates and railroad rates would remain at current levels. There is, however, every reason to expect this would not be the case. As discussed above, increased demand for motor carriage would tighten trucking markets and invariably lead to rate increases.[30]

In the case of rail, the increases in train delays imply higher costs for all rail shipments within the region. Thus, it is likely that rail rates would increase to some degree for everyone – current estimates suggest that train delays alone would increase carrier costs by roughly 10 percent.[31] However, there is a larger issue, already noted above. The displaced waterway traffic would have to *buy* its way onto an already lean and busy railroad network, providing railroads with the incentive to make the necessary routing changes. This virtually guarantees the displaced waterway traffic would move at rates that are significantly higher than those presently observed.

[30] Higher motor carrier rates reflect truckers' opportunity costs, but do not account for increased damages to roadways.
[31] Or in the case of existing shippers, the price may be exacted through a lower quality of service.

Bearing all these caveats in mind and based on existing rail rates that only reflected increases in known costs, estimated cost increases for the movement of grain in the wake of an unscheduled LaGrange Lock & Dam closure are provided in Table 21. Similar values for an unplanned closure at Lock & Dam 25 are provided in Table 22.

Table 21 – Diversion Costs for an Unplanned Closure at LaGrange Lock & Dam

	Under Average Traffic	At 2017 Traffic Volumes	With No Mississippi River Alternative
Trucking Costs	$316,200,000	$246,500,000	$316,200,000
Railroad Costs	$0	$148,500,000	$1,069,200,000
Barge Costs	$186,000,000	$135,000,000	$0
Ancillary Costs	$43,750,000	$40,250,000	$63,000,000
TOTAL	$545,950,000	$556,750,000	$1,351,200,000
Baseline Cost	$316,250,000	$290,950,000	$455,400,000
Cost Difference	$229,700,000	$265,800,000	$895,800,000

Table 22 – Diversion Costs for an Unplanned Closure at Lock & Dam 25

	Under Average Traffic	At 2017 Traffic Volumes	With No Illinois River Alternative
Trucking Costs	$471,750,000	$561,000,000	$726,750,000
Railroad Costs	$518,400,000	$716,740,000	1,692,900,000
Barge Costs	$133,500,000	$148,500,000	$0
Ancillary Costs	$64,750,000	$77,000,000	$99,750,000
TOTAL	$1,188,400,000	$1,503,240,000	$2,519,400,000
Baseline Cost	$468,050,000	$556,600,000	$721,050,000
Cost Difference	$720,350,000	$946,640,000	$1,798,350,000

7. STUDY CONCLUSIONS

7.1 SUMMARY OF FINDINGS

The findings of this analysis suggest that possible disruptions to available navigation in the upper Mississippi basin could produce an array of new demands for truck and rail transportation. These new demands range in magnitude from the modest requirements of an unplanned outage at LaGrange on the Illinois River during an average year to the almost unimaginable stresses owing to a Lock & Dam 25 closure on the Mississippi during a year of peak production when no excess Illinois River terminal capacity is available.

In the face of a lesser disruption at either lock, it seems likely that upper basin terminals and the farmers and elevators that supply them could successfully accommodate diverted waterway traffic, but at significantly higher transportation costs. Similarly, under moderate conditions, it is likely that the rail-served export terminals on the Louisiana Gulf could handle the diverted quantities, but these conclusions are predicated on a variety of assumptions and contingencies that leave them fragile, if not somewhat suspect.

Regarding rail transport between the upper Mississippi and Illinois basins and export terminals on the Louisiana Gulf, simulations using the University of Tennessee's *RAILNET* analytical platform demonstrate similarly delicate outcomes. Under the three simulated disruptions, the diverted grain traffic moved from basin to export without causing too much disruption, but achieving this outcome depends on an ability and willingness to rebalance rail rates in ways that sometimes redirect existing rail traffic to alternative routes. Assuming the railroads *could* identify and execute these rate changes, it is not clear what incentive they would need to do so, or if they would do so at all. If the railroads understand that the lock outage and related increases in demand are transient, they may not be willing to agitate existing customers (and revenue flows) even if the transitory profits associated with the diverted grain are quite large.[32]

There is at least one robust conclusion—responding to an unscheduled lock outage at LaGrange or Lock & Dam 25 would be costly. Depending on the scenario, estimated diversion costs range between $230 million and $1.6 billion and these estimates do not account for the motor carrier and rail rate increases that would inevitably be necessary to incent carrier responses. While our informal estimates probably depict a correct order of magnitude, actual costs, if ever observed, are sure to be considerably higher.

7.2 CONCLUDING COMMENTS

For more than a century, U.S. policy has been to support commercial navigation by authorizing and expending funds to build and maintain necessary navigation infrastructure. The nation's private sector entities—its shippers, railroads, and motor carriers—have adapted to this course, based on the assumption that the federally sponsored navigation system would remain a dependable transportation resource. Accordingly, in the upper Midwest, agricultural shippers

[32] There are regulatory vehicles through which the Surface Transportation Board could "direct" railroad services and pricing. However, historically, the STB has not shown a willingness to intervene to any great extent in these sorts of settings.

have come to rely heavily on available barge transportation and the region's railroads have found it unnecessary to develop and sustain a level of infrastructure that would allow them to seamlessly accommodate a large, unforeseen volume of agriculture-related waterway traffic. In recent decades, this freedom has been of growing importance to a railroad industry that is seeking to shed excess capacity in favor of lean networks and highly predictable service demands.

Within this context, the analysis presented here considered how rail-served grain terminals and their serving rail carriers could and would respond to lock failure-related surge in the demand for the movement of grain to export. The current system of grain collection, transport, and export from upper Midwest origins through the Louisiana Gulf is not designed to rely on rail transportation and the railroads are not designed to support this traffic. In the face of a long-run federal decision to reduce the extent of the navigation system that serves the upper basin states, railroads and rail-served terminals would need to invest in additional capacity. However, in the short-run, the economic interests of all concerned are best served by tirelessly ensuring the reliability of the navigation system that is in place.

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For any errors and omissions in the report, the author bears sole responsibility.

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