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Economic and Environmental Impacts of the Columbia-Snake River Extended Lock Outage

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Economic and Environmental Impacts of the Columbia-Snake River Extended Lock Outage

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Transportation and Environmental Assessment of the Impact of Extended Lock Outages: the Columbia-Snake River System
Final Report

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FPTI Research Reports: Background and Purpose

This is the twelfth of a series of reports prepared by the Freight Policy Transportation Institute (FPTI). The reports prepared as part of this Institute provide information to help advance knowledge and analytics in the area of transportation policy.

FPTI is funded by the United States Department of Transportation (USDOT). Dr. Ken Casavant of Washington State University is Director of the Institute. A Technical Advisory Committee (TAC) comprised of Federal, State and local representatives has been assembled in order to identify relevant and pressing issues for analysis, apply rigorous theoretical and analytical techniques and evaluate results and reports. The TAC includes Jerry Lenzi (WSDOT) as Chair, Ed Strocko (USDOT), Randall Resor (USDOT), Bruce Blanton (USDA), Timothy Lynch (American Trucking Association), Rand Rogers (MARAD), John Gray (AAR) and Daniel Mathis (FHWA – Washington State). The following are key goals and objectives for the Freight Policy Transportation Institute:

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- Address the need for improved intermodal freight transportation, as well as policies and actions that can be implemented to lower operating costs, increase safety and lower environmental impacts of freight transportation nationwide
- Improve freight transportation performance to specific industries and sectors of the economy

For additional information about the Freight Policy Transportation Institute or this report, please contact Ken Casavant at the following address:

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1. Simmons, Sara and Ken Casavant. FPTI Research Report #1. "Historical Waterborne Commerce on the Columbia-Snake River System: Commodity Movements Up and Down River, 1991-2010." November 2010.

2. Simmons, Sara and Ken Casavant. FPTI Research Report #2. "Industry Preparations for the Columbia-Snake River Extended Lock Outage, July – December 2010." February 2011.

3. Khachatryan, Hayk, Jeff Poireman, and Ken Casavant. FPTI Research Report #3. "Determinants of Consumer Choice for Biofuels." March 2011.

4. Khachatryan, Hayk, Ken Casavant, Eric Jessup, Jie Chen, Shulin Chen, and Craig Frear. FPTI Research Report #4. "Biomass Inventory Technology and Economics Assessment." March 2011.

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9. Simmons, Sara and Ken Casavant. FPTI Research Report #9. "Industry Reactions to the Columbia-Snake River Extended Lock Outage, December 2010 – March 2011." June 2011.

10. Simmons, Sara and Ken Casavant. FPTI Research Report #10. "Return to the River: Columbia-Snake River Extended Lock Outage, April – June 2011." July 2011.

11. Jessup, Eric. FPTI Research Report #11. "U.S. Renewable Fuels (Ethanol): Historical Policy and Future Prospects." May 2011

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BACKGROUND AND PURPOSE OF OVERALL STUDY

The Columbia-Snake River System in the Pacific Northwest recently underwent a massive and sustained lock outage, which eliminated barge transportation on much of the upper Columbia River and all of the Snake River. A shutdown of this length is unprecedented in the United States. The impact of this loss of a major mode of transportation and the impact on the demands of other modes of transportation were significant.

The goal of the outage was to make necessary major maintenance repairs for continued operation in the future. Such extended lock closures are not normal but this river system, as many facilities throughout the nation, required massive investments to maintain the integrity of the system and to continue to generate the acknowledged long term benefits of the navigation system.

The economic value of this transportation link is apparent from the commerce that flows up and down the system. This river system is the #1 U.S. wheat export gateway, #1 U.S. barley export gateway, #1 West Coast paper and forest products gateway, #1 in West Coast mineral bulk exports and #1 in West Coast auto imports. This inland system supports 10 million tons of cargo and is connected to the deep draft channel and ocean shipping which supports over 45 million tons of cargo.

The closure of these locks, which occurred from December 10, 2010 to March 24, 2011, had impacts on shippers, river carriers, roads, alternative modes, ports, communities, economic development decisions, energy and the environment as these entities reacted to the temporary loss of this transportation alternative.

This is the final report by the Freight Policy Transportation Institute (FPTI) for the Transportation and Environmental Assessment of the Impact of Extended Lock Outages: the Columbia-Snake River System.

The overall scope of this study includes the following objectives:

- Empirically determine historical and current use of the transportation system surrounding and including the inland navigation mode in typical periods of time, by inventorying and describing the shippers, carriers, ports and attendant river flows by timing, commodity and location on the river
- In months leading up to actual lock closure on the Columbia-Snake River System, determine shipper decisions, as they prepare for the outage, causing changes, and impacts of those changes, in the usage of the river navigation mode and attendant modes/functions
- During actual lock closure, collect and analyze rates and modal costs to determine incidence and magnitude of increased marketing costs

- Following the lock closure, evaluate the timing and volume of shipments and impacts as the river traffic returns to its pre-lock closure condition
- Determine the impacts on the environment in the form of energy consumption and emissions production during the four major phases of the study

The four specific work phases identified for this study are:

- Phase 1 – Historical Documentation of River Movements Prior to the Closure
- Phase 2 – Documentation, Modeling and Interviews Prior to the Closure
- Phase 3 – Documentation, Modeling and Interviews During the Closure
- Phase 4 – Documentation, Modeling and Interviews After the Closure

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The contents of this report reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the United States Department of Transportation, Transportation Northwest or individual commodity shippers and carriers. This report does not constitute a standard, specification or regulation.

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Economic and Environmental Impacts of the Columbia-Snake River Extended Lock Outage

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Economic and Environmental Impacts of the Columbia-Snake River Extended Lock Outage

Executive Summary

This report's main objective is to analyze the change in rates and modal costs for shippers, commodity industries and ports prior to, during and after the fifteen week lock outage and to determine the impacts on the environment in the form of energy consumption and emissions production prior to, during and after the lock outage.

Waterborne movements are one of the more economical and cost-efficient methods of transport among all modes of transportation, comprising a key component of the Pacific Northwest multimodal transportation system. Commodity shipments moving through this river system were recently halted for 15 weeks during the winter of 2010-2011 for an unprecedented extended lock outage.

The specific research objectives and methodology for the entire study as well as economic and environmental impacts are reviewed in Section 1. Section 2 summarizes the four phases of the study and includes data and sections from those commentaries. Additional tables are available in Appendix A. Section 3 reviews the economic costs of the lock outage for major commodity industries, shippers and ports. Section 4 discusses the environmental impacts of the lock outage. This section begins with a review of literature of energy intensity coefficients and emissions coefficients for various transportation modes. Then energy used via different modes prior to and during the lock outage are calculated and discussed. The same is done for emissions produced during these time periods. Section 5 provides a summary of the entire study and describes the value of the river.

Historically, about three times more total tonnage travels downriver than upriver. Wheat, forest products, crushed rock products, grains other than wheat, vegetable products, processed grains and paper products are the commodity groupings that traveled most often and in the greatest amounts downriver from 1991 to 2010. It is interesting to note that these commodities are of an agricultural nature and generally not of man-made materials. Industrial commodities, such as gasoline, diesel fuels, landfill material, fertilizer and smelted products most often and in the most amounts travel upriver.

During the months of December through March, 1.7 million tons of commodities typically travel downriver. Wheat, forest products, vegetable products, processed grains, other agricultural products, crushed rock products, iron ore products, grains other than wheat and smelted products comprise 97 percent of all tonnage shipped downriver from December to March. Also during the months of December through March, 631,000 tons of commodities typically travel upriver. Diesel fuels, gasoline, landfill material, forest products, fertilizer and smelted products comprise 98 percent of all tonnage shipped upriver from December to March. Therefore, these

commodities were expected to be impacted the most by the lock outage and these industries planned accordingly to continue shipments and deliveries during the lock outage.

During the six months before the lock outage, monthly total tonnage traveling upriver remained quite stable, whereas the total tonnage of downriver shipments ranged from a high of 695,000 in August to a low of around 319,000 tons in December. The monthly downriver high in August for this six month period is likely due to the start of the wheat harvest as wheat makes up about 70 percent of all downbound shipments on the Columbia-Snake River.

Major commodities in general moved in large and above average quantities on the Columbia-Snake River during the months of July through December 2010 in order to prepare for the extended lock outage. Those major commodities moving downriver that rose above average levels for at least two months included wheat, forest products, iron ore products, vegetable products, processed grains and agricultural products. Those major commodities moving upriver that rose above average levels for at least two months included diesel fuel and fertilizer.

These large shipments in the months leading up to the December 2010 reveals that commodity industries were preparing for the extended lock outage by shipping more products prior to the closure date. By sending shipments prior to the outage, industries accumulated products in Portland, Oregon and Vancouver, Washington so that customers had easy access to shipping and international trade while the Columbia-Snake River was closed. Sending shipments early also allowed industries to fill orders prior to the outage rather than missing out on commerce and to avoid increased costs of alternate modes of transportation while barge transportation was curtailed.

Since wheat is such a large volume client of barge transportation, 75 percent of all downriver movements, it is useful to pay particular attention to wheat and its movements in the Pacific Northwest prior to the lock outage.

Southern Washington, including the county of Whitman, ships the highest percentage of wheat in the Pacific Northwest. However, in general, Washington wheat elevators move 70 percent of all shipments from the three states.

Wheat firms in the Pacific Northwest move most of their product, about 61 percent, by truck-barge, due to the low cost and convenience of barge transportation. However, Northern Washington firms mostly employ rail to transport wheat, about 71 percent.

Northern Idaho and Northern Washington elevators both ship most of their wheat from December to March instead of from August to November, in contrast to the rest of the regions. For all regions besides Northern Idaho and Washington, the majority of wheat is shipped from August to November, then from December to March and the least amount of wheat is shipped from April to July.

On average, truck-barge is at least 10 cents per bushel less than rail and truck. Direct truck to final market is the most expensive form of transportation in the Pacific Northwest at 89 cents per bushel and is seldom used. Northern Washington and Southern Idaho are the only regions in which barge is more costly than both rail and truck.

Along with preparing for monetary impacts, barge lines prepared customers and employees to weather the downturn in business. The barging industry in the Pacific Northwest briefed customers, employees and suppliers on the necessity of the extended lock outage, the required time to complete repairs and also looked for ways to continue benefit packages for employees during the extended lock outage.

In contrast to barge companies, which planned to lose substantial business for the entirety of the lock outage, rail lines prepared for the increase in cargo loads. Rail lines stepped forward to aid customers, producers and industries in continuing shipments through the extended lock outage. Such preparation included advertising, identifying inland markets, reaching out to shippers and industries that may need transportation during the outage, partnering with local ports to aid in the movement of products and predicting expected shipment volumes.

Since the large majority of shippers, carriers and industries did not have barge transportation available during the lock outage (and would have used barge transportation had the river been navigable) these entities used two alternatives to transport commodities: rail and truck. Notably, products were transported by truck or a combination of truck and rail. This is interesting to note since most industry representatives stated prior to the lock outage that products transported normally by barge would move solely by rail as it is inexpensive and can haul larger loads than truck.

The largest volume of tonnage transported by truck and rail instead of by barge during the lock outage was petroleum (gasoline and diesel fuels). The second largest volume to travel by truck rather than barge during the lock outage was waste materials.

Since a few barge companies had access to Bonneville Lock and Dam, which was open for 11 of the 15 week outage, a total of 377,000 tons were shipped downriver between December 10, 2010 and March 24, 2011. During the lock outage, commodity movements by barge were 79 percent below average. The major commodities with the largest volume of downriver shipments during the outage were wheat, forest products, crushed rock products and smelted products.

Around 10,500 tons were shipped upriver between December 10, 2010 and March 24, 2011, mostly manufactured equipment and machinery. This commodity was shipped in mass quantity during the month of February 2011. This surge in upriver shipments of this commodity is due to the U.S. Army Corps of Engineers’ construction and assembly of lock gates and repairs. The Corps reported that during the month of February, two gate leaves constructed for The Dalles Lock and Dam originated in Portland and passed through Bonneville hence explaining the large movement of manufactured equipment and machinery during this month.

The original Pacific Northwest wheat survey served as a benchmark for volumes, rates and modal choices for wheat elevators in the Pacific Northwest during times in which barge, rail and truck transportation were all available. The second survey allowed comparison of normal volumes, rates and modal choices for wheat elevators to those during the extended lock outage.

During this period, Northern Washington shipped the highest percentage of wheat in the Pacific Northwest, over 57 percent. This represents a shift in volume shipped; Southern Washington, including the county of Whitman, normally ships the highest percentage of wheat from the Northwest, about 35 percent. However, Northern and Southern Washington wheat elevators together moved 61 percent of all shipments from the three states during the lock outage, compared to 69 percent during a typical time period.

Most wheat firms in the Pacific Northwest moved the majority of their product, an average of 93 percent, by rail during the lock outage. However, Eastern Oregon and Southern Washington firms mostly employed trucking services to transport wheat from December 2010 to March 2010, about 40 to 75 percent, respectively.

Twenty percent of wheat coming from Eastern Oregon was shipped via truck-barge. This was because of one wheat elevator's access to the Columbia River and Bonneville Lock and Dam to head to Portland. This lock was open 11 weeks during the 15 week outage.

Shipping rates for truck and rail increased slightly in the Pacific Northwest during the lock outage. Additional costs, such as investment in storage expansion and shipping from alternative sources, were incurred by several firms in varying amounts. Railcars were unreliable for some elevators during the lock outage which led to unforeseen costs, delays and potentially lost business; the magnitude was uncertain.

Most barge companies temporarily laid off a significant number (from 35 percent to 67 percent) of their employees, including boat crews, in order to reduce costs. Some barge companies offered job sharing and reduced employees' work hours rather than lay off their entire staff. All of the barge lines were able to continue benefit packages for employees during the extended lock outage.

In contrast to barge companies, which lost business for the majority of the lock outage, rail lines experienced an increase in cargo loads during the lock outage. Rail lines in the Pacific Northwest dealt with greater than normal volumes, additional products that would have moved by barge, increased crew numbers, additional days of operation and a few extra trains per week. Part of this experience included rail lines reaching out to industries that needed transportation during the outage and partnering with local ports to aid in the movement of products that would normally travel by barge.

The Port of Portland rewarded shippers for their continued support and patronage by subsidizing rail and truck transportation for industries that normally use barge to ship commodities to the Port. Port commissioners intended that this subsidy would encourage carriers and industries to continue business with Portland during and after the outage, instead of seeking commerce with other local ports. Indeed, no carriers or industry customers of the Port of Portland were lost to other local ports.

During the three months following the lock outage, traffic returned to the river with major surges above past movement levels; this is especially true in movements downriver. Between April 2011 and June 2011 about five times more tonnage traveled downriver than upriver, compared to the typical three to one movement. The fact that downriver traffic increased relative to upriver traffic during this three month period suggests that industries that ship products downriver were more impacted by the lock outage as these entities chose to heavily transport commodities after the lock outage rather than during.

Major commodities in general moved in near and above average quantities on the Columbia-Snake River during the months of April through June 2011 in order to ship products that had been halted by extended lock outage. Those major commodities moving downriver from April to June 2011 that rose above average levels for at least two months include forest products and wheat. Those major commodities moving upriver that rose above average levels for at least two months during this time period include fertilizers and primary non-ferrous metallic products.

Commodity movements prior to and after the extended lock outage were also examined as to determine whether industries were able to effectively reconfigure commodity shipments that would have shipped by barge during the extended lock outage.

During the three months before the lock outage on the Columbia-Snake River, monthly total shipments downriver were significantly higher than corresponding historic averages. Likewise, total monthly downriver wheat shipments were significantly higher than their corresponding historic averages. September 2010 downriver shipments of wheat were a remarkable 65 percent above average. Shipments of wheat in October 2010 were 80,000 tons above average or an increase of 20 percent. Lastly, downriver wheat movements in November 2010 were 27 percent above average. These significantly above average movements show that industries and shippers were prepared to ship their products prior to the lock outage as to avoid additional time and expenses to ship commodities by rail or truck during the lock outage.

After the lock outage, during the months of April through June 2011, monthly total shipments downriver were significantly above average for April and May, but below average for the month of June. Total monthly wheat movements made downriver, however, were above average for all three months following the lock outage. In April 2011, total wheat shipments moving downriver reached 758,000 tons and were a significant 118 percent above the 2007-2009 April average. Total wheat shipments during the month of May were 84 percent above average. Finally, June 2011 shipments of wheat downriver were also above average by 88 percent.

This surge in shipments during the two months after the lock outage is evidence that industries waited to transport their goods until after the lock outage rather than during. This is likely due to the fact that barge transportation is more economical and more convenient for those industries that regularly use waterborne transportation. It appears that since the wheat industry prepared so well for the lock outage, elevator managers did not need to ship as much grain during the lock outage and were able to wait until the lock system reopened.

During a transportation disruption, such as the extended lock outage, alternative modes are used more frequently and heavily as barge transportation is unavailable. The lock outage on the Columbia-Snake River forced commodities that would regularly travel by barge to be shifted to rail and truck. As a result, transportation costs incurred a 37.4 percent increase. This dramatic increase is mostly due to the large global demand for wheat due to recent droughts in Eastern Europe. Also, truck and rail firms increased rates during the lock outage to capitalize on the lack of barge transportation.

In addition, energy consumed by truck and rail transportation increased and barge energy consumed decreased with the lack of river access during the lock outage. The overall result in energy intensity during the year of the lock outage was an increase of 10 percent more Btu's consumed. This increase in energy use is logical as more tonnage was shipped from August 2010 to July 2011 than during a typical year and truck was mostly used to replace barge during the lock outage, which is more energy intense. However, energy consumed per ton decreased 4.8 percent due to the heavy use of rail, which is more energy efficient than barge or truck, and the increased use of barge prior to and after the lock outage.

Along with energy consumption, emissions production also increased due to the lock outage. The total change in emissions due to the loss of barge during the lock outage caused a 9 percent increase in overall emissions from the transportation commodities. Percentages of hydrocarbons, carbon monoxide, nitrous oxides and particulate matter all increased; sulfur oxides were the only emissions component to decrease. Again, the general increase in emissions is a result of the increase in tonnage shipped and alternative modes used during the lock outage year in comparison to a typical year. Rail produces more emissions, including all components, when compared to barge. Truck produces more hydrocarbons and particulate matter when compared to barge. Therefore, the general increase in emissions during a transportation disruption like the extended lock outage is logical and expected.

Introduction

Waterborne movements are one of the more economical and cost-efficient methods of transport among all modes of transportation, comprising a key component of the Pacific Northwest multimodal transportation system. More than 35 commodities travel up and down the Columbia-Snake River annually. These commodity shipments move through eight separate locks and dams, including the Snake River dams: Lower Granite, Little Goose, Lower Monumental and Ice Harbor; followed downriver by the Columbia River dams: McNary, John Day, The Dalles and Bonneville. Commodity shipments moving through this river system were recently halted for 15 weeks during the winter of 2010-2011 for an unprecedented extended lock outage.

This report's main objective is to analyze the change in rates and modal costs for shippers, commodity industries and ports prior to, during and after the fifteen week lock outage. The report's secondary objective is to determine the impacts on the environment in the form of energy consumption and emissions production prior to, during and after the lock outage. In addition, a summary of the four previous reports is included to concisely discuss the study and key findings.

Specific research objectives and methodology for the entire study as well as economic and environmental impacts are reviewed in Section 1. Section 2 summarizes the four phases of the study including data and sections from those commentaries. Additional tables are available in Appendix A. Section 3 reviews the economic costs of the lock outage for major commodity industries, shippers and ports. Section 4 discusses the environmental impacts of the lock outage. This section begins with a review of literature of energy intensity coefficients and emissions coefficients for various transportation modes. Then energy used via different modes prior to, during and after the lock outage are calculated and discussed. The same is done for emissions produced during these time periods. Section 5 provides a summary of the entire study and describes the value of the river.

1. Research Objectives and Analysis Approach

The primary objectives of the study are as follows:

Phase 1:

- To describe in detail the historical commodity movements along the Columbia-Snake River for the period from 1991-2010
- To identify the general trends and seasonality of historical commodity movements
- To identify major commodities that could be affected by the extended lock outage

Phase 2:

- To identify the general preparations of individuals for the extended lock outage, including those of governments, industries, carriers and private entities
- To describe in detail the major commodity movements along the Columbia-Snake River for the six month period prior to the extended lock outage (July – December 2010)

Phase 3:

- To identify the general impacts on, and decisions by, individuals relative to the recent extended lock outage, including those of governments, industries, carriers and private entities
- To describe in detail the major commodity movements by rail and truck in the Pacific Northwest for the 15 week period of the extended lock outage (December 10, 2010 – March 24, 2011)

Phase 4:

- To describe in detail the major commodity movements along the Columbia-Snake River for the three month period following the extended lock outage (April – June 2011)

Final Report:

- To analyze the change in rates and modal costs for shippers, commodity industries and ports prior to, during and after the fifteen week lock outage
- To determine the impacts on the environment in the form of energy consumption and emissions production prior to, during and after the lock outage

Information regarding economical impacts on industries and alternative modes (rail and truck) were provided by shippers, river carriers, government divisions, industry personnel and ports. Information was drawn through interviews, transportation conferences, meetings, interviews and government and industry websites. A list of those interviewed and surveyed is available in

Appendix B. Tons and miles traveled were also provided by shippers, river carriers, government divisions, industries and ports; this information was used to calculate environmental impacts caused by the lock outage.

The data analyzed in this report captures commodities shipped over the Columbia-Snake River and includes detailed information by month, direction and total commodity tonnage transported during each month. However, this final report focuses on the nine major commodity types discussed below. These commodities were selected as they were the highest volume movements over the last twenty years. Most of these commodity volumes decreased in the months of December 2010 through March 2011. The commodities sand, gravel and stone moving downriver; primary non-ferrous metallic and fabricated metal products moving upriver and downriver; and forest products moving upriver have all been eliminated from the list due to of lack of shipment and/or shipments were not reported during the lock outage. For previous major commodity shipment volumes and other related data, refer to Section 2.

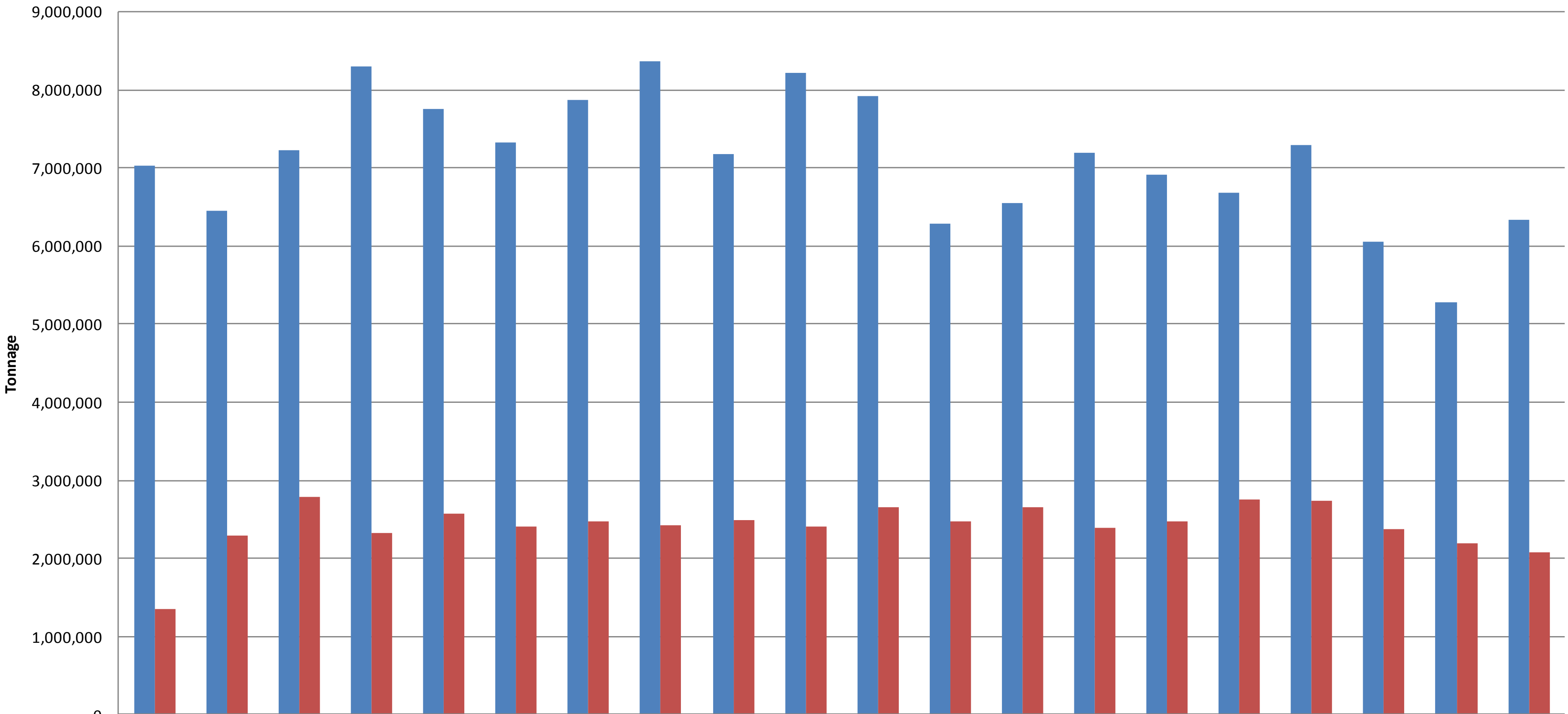
2. A Real Time Assessment of a Major Transportation Disruption: the Columbia-Snake River Extended Lock Outage

2.1 Historical Waterborne Commerce on the Columbia-Snake River System, 1991-2010

Waterborne commodity movements discussed in this study are based on the total arrival and departure estimates of commodities from the Bonneville Lock and Dam. Bonneville was selected because it is the last receiving lock on the Columbia-Snake River and the first lock that sends goods upriver. The total amount of downriver shipments from the Columbia-Snake River departs through Bonneville en route to other cities and the ocean for access to international markets. Similarly, for upriver shipments, Bonneville is the first lock to receive goods that then travel to subsequent locks of the Columbia-Snake River system as well as markets inland.

Between 1991 and 2010, about three times more tonnage traveled downriver than upriver on the Columbia-Snake River. Previous analyses of barge transportation on this river system suggest that this trend has been consistent for the last 30 years. Annual total tonnage traveling upriver remained quite stable between 1991 and 2010 at an average of 2.4 million tons, whereas the total tonnage of downriver shipments ranged from a high of 8.4 million tons in 1998 to a low of around 5.3 million tons in 2009 (Figure 2.1). As evident by the graph below, barge movements downriver have slowly decreased over the last ten years (2000 – 2010). The downturn in shipments during the last three years is likely due to two factors: 1) the economic recession which began in late 2008 and 2) at least two large multi railcar facilities in the Pacific Northwest have began to increase train loads, which include commodities that traditionally move by barge including wheat and forest products.

Fig. 2.1 Total Annual Downriver and Upriver Tonnage, 1991 - 2010



	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Downbound	7,021,050	6,444,707	7,233,188	8,302,379	7,749,124	7,324,887	7,866,260	8,369,857	7,180,553	8,221,105	7,925,508	6,288,914	6,556,068	7,191,187	6,910,057	6,676,339	7,285,489	6,054,799	5,280,671	6,342,682
Upbound	1,347,035	2,292,533	2,787,568	2,323,839	2,566,972	2,408,500	2,471,393	2,424,419	2,492,141	2,410,357	2,656,613	2,471,964	2,654,055	2,390,268	2,476,764	2,746,218	2,733,707	2,378,491	2,187,132	2,084,729

Source: U.S. Army Corps of Engineers Monthly Lock Tonnage Reports

Downriver Movements

Annual and monthly downriver shipments have comprised 75 percent of all waterborne movements on the Columbia-Snake River for the last twenty years. A total of 142 million tons were shipped downriver between 1991 and 2010. The commodities with the largest volume of downriver shipments over the twenty year span between 1991 and 2010 have been (in *descending* order of their yearly tonnage) wheat; forest products, crushed rock products, grains other than wheat, vegetable products, processed grains and paper products. It is important to note that all of these commodities are agricultural outputs which are sent to the west coast to be used within the nation and internationally.

During this time period, wheat comprised about 70 percent, or 98 million tons of the total 142 million tons, of commodities transported downriver (Table A.1, Appendix A). The second highest commodity by total tonnage was forest products at about 18.9 million tons or 13 percent of downriver shipments.

Upriver Movements

As mentioned above, about three times less tonnage travels upriver than downriver. Therefore, only 48 million tons were shipped upriver between 1991 and 2010. The commodities with the largest volume of upriver shipments over the twenty year span between 1991 and 2010 have been gasoline, diesel fuel, landfill material, fertilizer and smelted products. As downriver commodities are generally outputs, these upriver commodities are in general agricultural inputs.

The highest proportion of total upriver shipments, about 41 percent or 19.6 million tons of the total 48.3 million tons, was attributed to gasoline (Table A.2, Appendix A). The second highest proportion of total upriver shipments was for diesel fuel, comprising 17.5 million tons (about 36 percent of the total upriver tonnage for 1991-2010).

Commodity Movements during the Four Months of the Extended Lock Outage

To determine which commodities may be affected by the extended lock outage, data for the months of December through March for years 2008 through 2010 is discussed below. A table comparison of monthly shipments, total tonnage and percentages have been averaged monthly over the three year period for December through March to construct a standard time period in which the extended lock outage will occur. By using data from December to March to form an average time period, readers, shippers and policy makers can develop a good understanding of what has currently moved up and down the Columbia-Snake River System during the extended lock outage months and possibly hypothesize how particular commodities will be affected during the outage.

Downriver Movements

During the months of December through March, 1.7 million tons of commodities typically travel downriver through Bonneville Lock and Dam (Table 2.1). Wheat; forest products; vegetable products, processed grains and agricultural products; crushed rock products; iron ore products; grains other than wheat; and smelted products comprise 97 percent of all tonnage shipped downriver from December to March. Among the 1.7 million tons shipped during these four months, about 392,000 tons of commodities ship downriver in December, 452,000 tons in January, 500,000 tons in February and 339,000 tons in March.

Within the month of December, wheat shipments make up about 76 percent of all downriver shipments, forest products make up 8.5 percent and crushed rock products make up five percent (Table 2.1). During a typical January, wheat shipments comprise about 83 percent of all shipments, forest products make up nine percent and vegetable products, processed grains and agricultural products make up three percent. Within the month of February, wheat shipments make up about 81 percent of all shipments, forest products make up ten percent and vegetable products, processed grains and agricultural products make up three percent. Finally, during a standard March, wheat shipments comprise about 75 percent of all shipments, forest products make up 11 percent and crushed rock products make up six percent.

Table 2.1 Average Downriver Movements Through Bonneville, 2008-2010

Commodity Type	Month								Total	
	December		January		February		March			
	Tonnage	Percent	Tonnage	Percent	Tonnage	Percent	Tonnage	Percent	Tonnage	Percent
Forest Products	33,300	8.49	40,878	9.04	51,587	10.32	35,733	10.53	**161,498**	**9.59**
Sand, Gravel and Stone	18,767	4.79	216	0.05	5,091	1.02	20,343	5.99	**44,417**	**2.64**
Iron Ore Products	7,250	1.85	5,153	1.14	4,850	0.97	2,737	0.81	**19,989**	**1.19**
Smelted Products	2,452	0.63	3,491	0.77	3,077	0.62	2,022	0.60	**11,042**	**0.66**
Wheat	297,001	75.74	373,447	82.60	403,156	80.64	254,009	74.84	**1,327,614**	**78.86**
Corn, Rye, Barley, Rice, Sorghum and Oats	6,250	1.59	2,167	0.48	2,900	0.58	3,782	1.11	**15,098**	**0.90**
Agricultural Products	10,912	2.78	13,328	2.95	13,824	2.77	7,065	2.08	**45,128**	**2.68**
Other Minor (27) Commodities	16,217	4.14	13,408	2.97	15,435	3.09	13,697	4.04	**58,758**	**3.49**
Total	**392,148**	**100.00**	**452,088**	**100.00**	**499,921**	**100.00**	**339,387**	**100.00**	**1,683,543**	**100.00**

Upriver Movements

During the months of December through March, 631,000 tons of commodities typically travel upriver through Bonneville Lock and Dam (Table 2.2). Distillate fuel oils, gasoline products, waste materials, forest products, fertilizer and primary non-ferrous metallic products comprise 98 percent of all tonnage shipped upriver from December to March. Among the 631,000 tons shipped during these four months, about 153,000 tons ship upriver in December, 162,000 tons in January, 181,000 tons in February and 134,000 tons in March.

Within the month of December, diesel fuel makes up about 42 percent of all upriver shipments, gasoline makes up 35 percent and landfill material makes up 13 percent (Table 2.2). During a typical January, diesel fuel comprises about 44 percent of all upriver shipments, gasoline makes up 31 percent, landfill material makes up 15 percent and forest products make up 5 percent. Within the month of February, diesel fuel shipments comprise about 44 percent of all upriver shipments, gasoline makes up 35 percent, forest products make up four percent and landfill material makes up 12 percent. Finally, during a standard March, diesel fuel comprises about 49 percent of all upriver shipments, gasoline makes up 30 percent, landfill material makes up 12 percent and fertilizer makes up five percent.

Table 2.2 Average Upriver Movements Through Bonneville, 2008-2010

Commodity Type	Month								Total	
	December		January		February		March			
	Tonnage	Percent	Tonnage	Percent	Tonnage	Percent	Tonnage	Percent	Tonnage	Percent
Gasoline	53,259	34.75	50,620	31.16	63,936	35.29	40,591	30.21	**208,407**	**33.01**
Diesel Fuel	64,862	42.32	72,091	44.38	78,927	43.56	66,122	49.21	**282,002**	**44.67**
Fertilizer	4,511	2.94	3,504	2.16	4,031	2.22	6,481	4.82	**18,527**	**2.93**
Forest Products	3,350	2.19	7,567	4.66	6,800	3.75	2,267	1.69	**19,983**	**3.17**
Smelted Products	2,664	1.74	3,832	2.36	2,235	1.23	1,809	1.35	**10,539**	**1.67**
Landfill Material	19,980	13.04	23,989	14.77	21,550	11.89	15,559	11.58	**81,077**	**12.84**
Other Minor (31) Commodities	4,649	3.03	856	0.53	3,692	2.04	1,550	1.15	**10,746**	**1.70**
Total	**153,274**	**100.00**	**162,459**	**100.00**	**181,170**	**100.00**	**134,379**	**100.00**	**631,281**	**100.00**

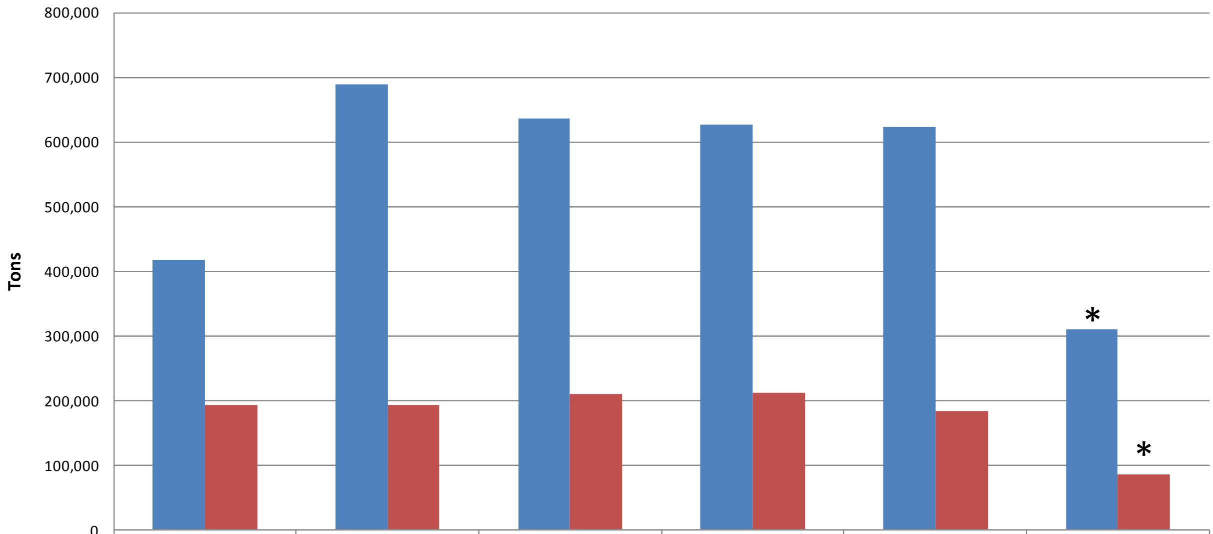
2.2 Industry Preparations for the Columbia-Snake River Extended Lock Outage, July – December 2010[1]

The commodity movements in the months leading up to the extended lock outage, July through December 2010, allow determination of how shippers and carriers prepared for the interruption in transportation created by the lock outage. One option for shippers and carriers to prepare for the extended lock outage was to increase barge shipments prior to December 2010; these preparations are evident in the following data.

Monthly total tonnage traveling upriver remained quite stable between July and November 2010 at an average of 198,000 tons, whereas the total tonnage of downriver shipments ranged from a high of 695,000 in August to a low of around 319,000 tons in December (Figure 2.2). The monthly downriver high in August for this six month period is likely due to the start of the wheat harvest as wheat makes up about 70 percent of all downbound shipments on the Columbia-Snake River.

[1] It should be noted that December 2010 data only includes the first nine days of the month. This is due to the fact that the extended lock outage began on December 10, 2010, thereby closing all locks from navigation on the Columbia-Snake River and halting all commodity movements.

Fig. 2.2 Total Monthly Downriver and Upriver Tonnage, July - December 2010



	Jul	Aug	Sep	Oct	Nov	Dec
Downbound	417,596	689,611	635,894	627,164	623,601	310,749
Upbound	192,492	192,634	210,873	212,338	183,683	86,459

Source: U.S. Army Corps of Engineers Monthly Lock Tonnage Reports
* December 2010 data only includes the first nine days of the month.

Downriver Movements

A total of 3.3 million tons were shipped downriver between July and December 2010. The commodities with the largest volume of downriver shipments over the six month period were wheat, forest products, crushed rock products, iron ore products and vegetable products.

During this time period, wheat comprised more than 75 percent, or 2.5 million tons of the total 3.3 million tons (Table A.3, Appendix A). The second highest commodity by total tonnage was forest products at 419,000 tons or 13 percent of the six month period's volume.

Upriver Movements

Around one million tons were shipped upriver between July and December 2010. The commodities with the largest volume of upriver shipments over the six month span were diesel fuel, gasoline, landfill material, crushed rock products and manufactured equipment and machinery.

The highest proportion of total upriver shipments, 48 percent or 519,000 tons of the total one million tons, was distillate, residual and other fuel oils (Table A.4, Appendix A). The second highest proportion of total upriver shipments was gasoline, jet fuel and kerosene products, comprising 332,000 tons (about 31 percent) of the total upriver tonnage for July through December 2010.

The upriver commodities, manufactured equipment and machinery, and sand, gravel and stone products were shipped in mass quantity from July to December 2010. This surge in upriver shipments for these commodities was due to the preparations of the U.S. Army Corps of Engineers for the construction and assembly of lock gates and repairs. Through the months of November and December, barges of crane equipment, lock doors and other construction equipment were shipped upriver in anticipation and preparation for the extended lock outage.

Total Movements

Major commodities in general moved in large and above average quantities on the Columbia-Snake River during the months of July through December 2010 in order to prepare for the extended lock outage. Those major commodities moving downriver that rose above average levels for at least two months include wheat, forest products, iron ore products, vegetable products, processed grains and agricultural products. Those major commodities moving upriver that rose above average levels for at least two months include diesel fuel and fertilizer.

These large shipments in the months leading up to December 2010 reveals that commodity industries were preparing for the extended lock outage by shipping more products prior to the closure date. By sending shipments prior to the outage, industries accumulated products in Portland, Oregon and Vancouver, Washington so that customers had easy access to shipping and international trade while the Columbia-Snake River was closed. Sending shipments early also allowed industries to fill orders prior to the outage rather than missing out on commerce and to avoid increased costs of alternate modes of transportation while barge transportation was curtailed.

Pacific Northwest Wheat

Since wheat is such a large volume client of barge transportation, 75 percent of all downriver movements, it is useful to pay particular attention to wheat and its movements in the Pacific Northwest prior to the lock outage.

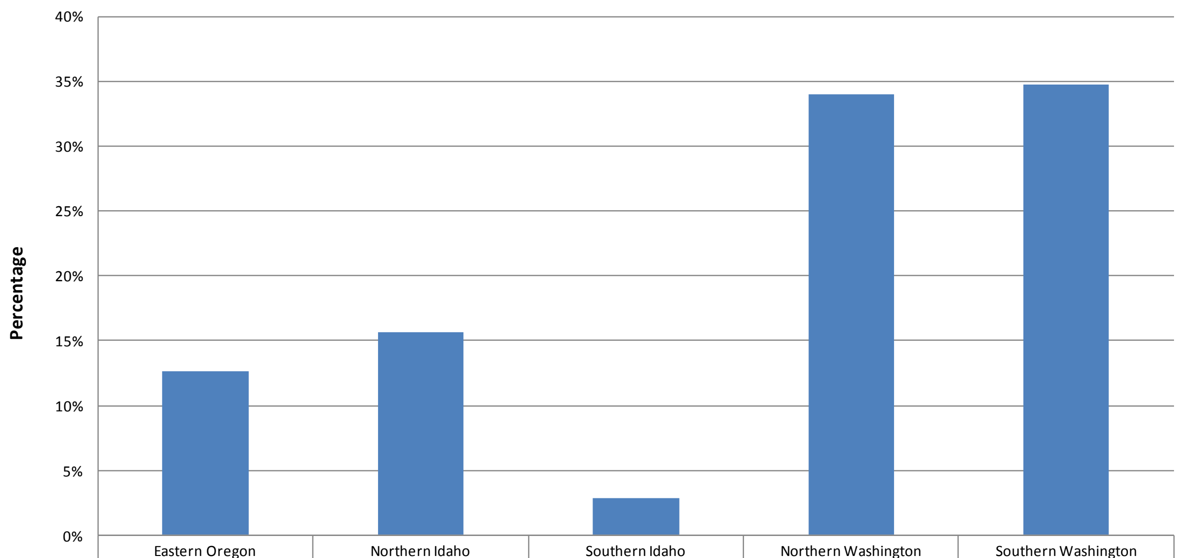
The Pacific Northwest (Washington, Oregon and Idaho) has available a three pronged transportation system: rail, barge and trucking. Therefore, wheat (in particular soft white wheat) has three different potential modes of transportation, allowing wheat producers, elevators, shippers and carriers to select the most efficient and/or economical mode or modes of travel. In order to capture the options and decisions of wheat producers, elevators and shippers when it comes to wheat transportation, a survey of wheat elevators in the Pacific Northwest was conducted. This provided the baseline scenario so that possible changes brought on by the extended lock outage can be evaluated.

Once the results were compiled, the 26 firms interviewed were divided into specific regions of the Pacific Northwest. Idaho elevators were grouped into two regions, Northern (5 firms) and

Southern (3 firms), by an imaginary line extending from Oregon's border with Washington. Washington was divided into Northern (5 firms) and Southern (8 firms) by I-90, a major highway through Washington. For example, the city of Wenatchee is north of I-90, so any elevators in that city would be considered Northern Washington. Oregon was simply grouped as Eastern Oregon since all 5 firms were located east of the Cascade Mountain Range, a common divider between the west and east sides of Oregon.

Southern Washington, including the county of Whitman, ships the highest percentage of wheat in the Pacific Northwest. However, in general, Washington wheat elevators move 70 percent of all shipments from the three states (Figure 2.3).

Fig. 2.3 Percentage of Annual Wheat Tonnage Shipped by Survey Respondents



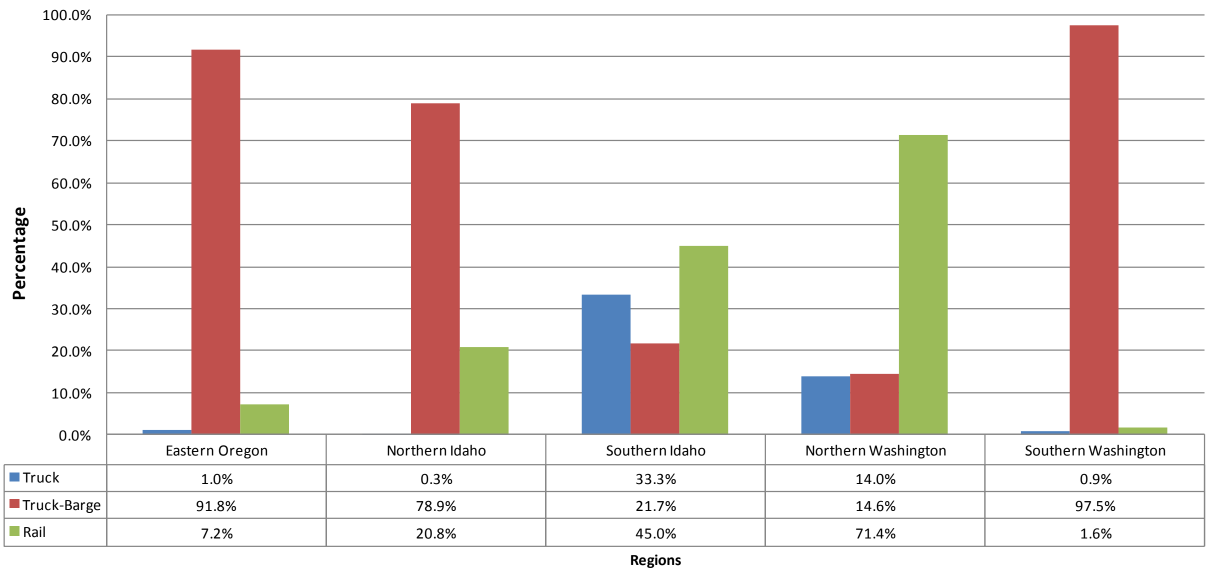
	Eastern Oregon	Northern Idaho	Southern Idaho	Northern Washington	Southern Washington
Wheat Shipped	12.7%	15.7%	2.9%	34.0%	34.8%

Source: Elevator Firm Survey (Washington, Oregon and Idaho) – Washington State University

Wheat firms in the Pacific Northwest move most of their product, about 61 percent, by truck-barge, due to the low cost and convenience of barge transportation. However, Northern Washington firms mostly employ rail to transport wheat, about 71 percent (Figure 2.4).

Thirty three percent of wheat coming from Southern Idaho and 14 percent from Northern Washington is shipped via truck to a final market (Figure 2.4). This could be because of the isolated nature of these regions or close proximity to flour mills, breweries and other facilities that process grain.

Fig. 2.4 Annual Percentage of Wheat Shipped via Various Transportation Modes



Source: Elevator Firm Survey (Washington, Oregon and Idaho) – Washington State University

On average, truck-barge is at least 10 cents per bushel less than rail and truck. Direct truck to final market is the most expensive form of transportation in the Pacific Northwest at 89 cents per bushel and is seldom used (Table 2.3). Northern Washington and Southern Idaho are the only regions in which barge is more costly than both rail and truck.

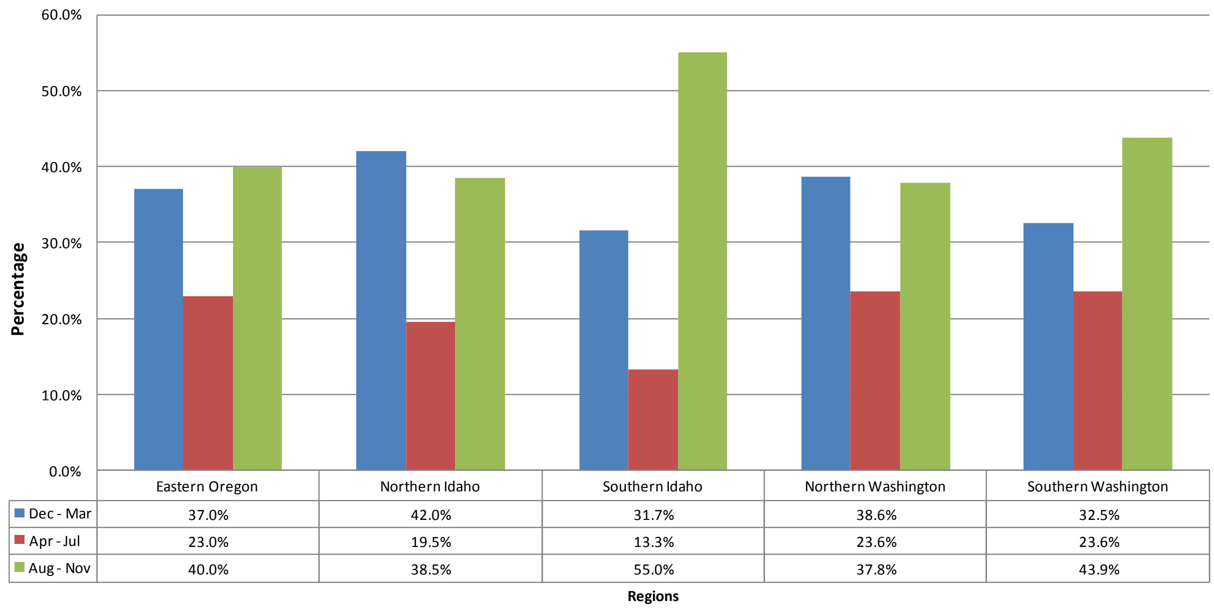
Table 2.3 Typical Wheat Transportation Rates by Survey Respondents

Region	Number of Firms	Average Rate in Cents per Bushel		
		Truck	Truck-Barge	Rail
Eastern Oregon	5	$0.50	$0.29	$0.58
Northern Idaho	5	$1.50	$0.58	$0.73
Southern Idaho	3	$0.71	$0.86	$0.83
Northern Washington	5	$0.52	$0.57	$0.54
Southern Washington	8	$1.22	$0.47	$0.55
Pacific Northwest	**26**	**$0.89**	**$0.55**	**$0.65**

Source: Elevator Firm Survey (Washington, Oregon and Idaho) – Washington State University

Northern Idaho and Northern Washington elevators both ship most of their wheat from December to March instead of from August to November, in contrast to the rest of the regions. For all regions besides Northern Idaho and Washington, the majority of wheat is shipped from August to November, then from December to March and the least amount of wheat is shipped from April to July (Figure 2.5).

Fig. 2.5 Percentage of Wheat Shipped by Season by Survey Respondents



Source: Elevator Firm Survey (Washington, Oregon and Idaho) – Washington State University

Industrial, Regional and Governmental Preparations for the Extended Lock Outage

The authors conducted a broad survey and interview concerning the activities and preparations of the actors in the region for the extended lock outage. The preparations and plans of these entities are discussed below.

Wheat

Since the wheat industry relies so heavily on barge transportation, this industry has been preparing customers and planning alternate transportation methods and storage since 2009. According to interviews, the wheat industry in the Pacific Northwest took a number of actions to prepare for this unprecedented outage, including notifying customers, shipping wheat prior to the extended lock outage and shipping wheat by rail and truck.

U.S. Wheat Associates, wheat commissions of the three state region, producers and shippers knew about the extended lock outage since August 2009. The first issue that U.S. Wheat Associates tackled was to notify customers and producers of the unprecedented lock outage and how it could affect business. International and domestic customers were contacted and informed about the lock closure via email, telephone, brochures and international meetings. Pacific Northwest international and domestic wheat customers were advised by various entities that the extended lock outage was required to "make essential renovations to locks" and that the restoration of the Columbia-Snake River locks is an opportunity to augment the reliability, efficiency and safety of barge transportation for wheat. Customers overseas were also given options for alternative delivery dates for wheat; shippers could barge prior to or after the lock outage occurred. Rail and truck transportation were suggested and contact information was given to customers.

According to industry interviews, wheat shipments that normally moved by barge transportation would move by truck and rail during the lock outage. There are several 110 railcar loading facilities in the Pacific Northwest, including those located in eastern Washington and southern Idaho. These shippers plan to take on high volumes of wheat during the extended lock outage. Ritzville Warehouse Company, a grain elevator in Washington, expected three times the normal winter business during the lock closure. These railcar loading facilities have access to hundreds of miles of track and country elevators, which makes this mode of transportation efficient and affordable, more so than direct trucking, for traditional barge customers.

Petroleum: Gasoline, Jet Fuel and Kerosene; Distillate, Residual and Other Fuel Oils; and Lubricating Oils and Grease

According to the Washington State Department of Commerce, "petroleum companies [evaluated] all fuel supply points and distribution options throughout the region to ensure adequate supply and timely fuel deliveries to Eastern Oregon and Washington communities throughout the duration of the outage." Normally, fuels are barged from petroleum distribution terminals at Portland, Oregon and Pasco, Washington in order to supply eastern Washington and Oregon with petroleum. From Pasco, fuel is sent through the Chevron pipeline to Spokane, Washington for distribution or transported by tanker trucks to rural areas in eastern Washington and Oregon. The Washington State Department of Commerce and petroleum companies suggested three alternatives to barging 1.47 million gallons of fuel per day during the outage: 1) use of excess terminal and barge storage, 2) use of excess capacity on pipelines from Montana and Salt Lake City and 3) increased use of tanker trucks and tanker rail cars.

Forest Products, Lumber, Logs and Woodchips

The forestry industry planned to use truck and rail transportation as an alternative to barge during the extended lock outage. Woodchips, lumber, logs and pulp were expected to be shipped by these modes from December 2010 to March 2011.

Industries that purchase and use forest products also had to plan and prepare for the extended lock outage. Various paper companies in the Pacific Northwest accelerated their shipments by barge in the months prior to December 2010 to ensure they received their product and to avoid the cost increase of trucking and railing their entire loads during the outage time period. The paper industry also improved their supply of inputs by cleaning out inventories of storage units upriver from the Portland and Vancouver areas. One paper firm estimated that woodchip shipments during the lock outage could reach up to five truck deliveries per day from eastern Oregon.

Barge Lines

Along with preparing for monetary impacts, barge lines prepared customers and employees to weather the downturn in business. The barging industry in the Pacific Northwest briefed customers, employees and suppliers on the necessity of the extended lock outage and the required time to complete repairs, looked for ways to continue benefit packages for employees during the extended lock outage and aided customers in finding alternative transportation methods from December 2010 to March 2011.

Rail Lines

In contrast to barge companies, which planned to lose substantial business for the entirety of the lock outage, rail lines prepared for the increase in cargo loads. Rail lines stepped forward to aid customers, producers and industries in continuing shipments through the extended lock outage. Such preparation included advertising, identifying inland markets, reaching out to shippers and industries that may need transportation during the outage, partnering with local ports to aid in the movement of products and predicting expected shipment volumes.

Ports

In addition to coordinating shipments and storage of commodities during the outage, the Port of Portland offered to reward shippers for their continued support and patronage by subsidizing rail and truck transportation. A Port of Portland commissioner stated that the port paid carriers $400 per container for truck and rail shipments from Lewiston, Idaho and $250 per container for truck and rail shipments from Umatilla, Oregon. To subsidize patrons' alternative transportation modes, the Port of Portland set aside $800,000. Port commissioners intended that the subsidy would encourage carriers and industries to continue business with Portland during and after the outage, instead of seeking commerce with other local ports.

Pacific Northwest Waterways Association (PNWA)

Pacific Northwest Waterways Association (PNWA) in collaboration with the U.S. Army Corps of Engineers has been the main player and leader in preparations for the extended lock outage. PNWA is a non-profit organization that "advocates for federal policies and funding in support of regional economic development" (PNWA).

Preparations

- Accurately and promptly notified its members of the extended lock outage via email, website, phone calls and public announcements
- Conducted conferences for its members justifying the importance of the lock outage
- Suggested alternative means of transportation to its members

- Spoke to the public and press about the significance of the outage
- Followed the progression of preparations of its members and when necessary aided members with contacts and references

U.S. Army Corps of Engineers (USACE)

Preparations

- Performed risk analysis of the current lock navigation system to determine necessary replacements and repairs
- Accurately and promptly notified individuals of the Columbia-Snake River extended lock outage via email, website, phone calls and public announcements
- Hosted several teleconference for stakeholders discussing progress made, projects completed and plans for the future for each Columbia-Snake River lock
- Documented all progression in the lock rehabilitation made prior to the lock outage on the USACE website
- Planned the extended lock outage around salmon runs and heavy cargo months
- Moved accessories, lock gate equipment and other necessary supplies for the extended lock outage by barge transportation as to not clog major highways or railways
- Made plans for potential disruptions of the lock outage including bad weather, unexpected delays in construction and traffic
- Accelerated prep work for the three locks that will be receiving new gates so that repairs and replacements can stay on or ahead of schedule (e.g. added Sunday shifts)

2.3 Industry Reactions to the Columbia-Snake River Extended Lock Outage, December 2010 – March 2011

Commodity movements from December 2010 through March 2011 were selected for discussion as this period's data captures commodity movements during the actual extended lock outage. The commodity movements during the winter months allow determination of how shippers and carriers rerouted products via alternative modes during the interruption in transportation.

Since the large majority of shippers, carriers and industries did not have barge transportation available during the lock outage (and would have used barge transportation had the river been navigable) these entities used two alternatives to transport commodities: rail and truck. Notably, products were transported by truck or a combination of truck and rail (Table 2.8). This is interesting to note since most industry representatives stated prior to the lock outage that products transported normally by barge would move solely by rail as it is inexpensive and can haul larger loads than truck. But the actually usage of truck was higher, most likely due to the convenience of truck in transporting goods short distances or by routes in which rail track does not exist. Many industries, including wheat, forestry and waste management, chose to partially send their goods to different markets during the lock outage, which involved rerouting commodities to different areas, most of which were not conveniently located near rail track. Also, many products only traveled a short distance (100 miles or less) or in small amounts; loading and unloading commodities from railcars was deemed by shippers to be inconvenient for these small quantities of weight.

The largest volume of tonnage transported by truck and rail instead of by barge during the lock outage was petroleum (gasoline and diesel fuels). The volume of these commodities shipped from December 2010 to March 2011 was an estimated 460,500 tons (Table 2.4). The second largest volume to travel by truck rather than barge during the lock outage was waste materials, over 68,000 tons. Forest product volumes transported by truck and rail reached a tonnage of over 58,000 and wheat shipments by truck and rail were over 45,500 tons (Table 2.4). These volumes would have normally moved by barge.

Table 2.4 Rail and Truck Movements, December 2010 - March 2011

Commodity	Transportation Mode	Total Tonnage
Gasoline, Jet Fuel and Kerosene	Truck and Rail	184,192
Distillate, Residual and Other Fuel Oils	Truck and Rail	276,287
Fertilizer (Nitrogenous, Potassic, Phosphoric and Others)	Rail	1,500
Forest Products (Lumber, Logs and Woodchips)	Truck and Rail	58,283
Sand, Gravel, Stone and Crushed Rock	-	0
Iron Ore, Iron Steel Waste and Scrap	Rail	9,000
Primary Non-Ferrous Metal Products	-	-
Wheat	Truck and Rail	45,648
Corn, Rye, Barley, Rice, Sorghum and Oats	Truck	212
Vegetable Products, Animal Feed and Other Agricultural Products	Truck and Rail	33,978
Waste Material (Garbage, Landfill, Sewage and Waste Water)	Truck	68,250
Total		**677,349**

Source: Industry and shipping interviews, Washington State University

Since a few barge companies had access to Bonneville Lock and Dam, which was open for 11 of the 15 week outage, a total of 377,000 tons were shipped downriver between December 10, 2010 and March 24, 2011 (Table A.5, Appendix A). During a typical winter (December through March), over 1.75 million tons of commodities travel downriver; during the lock outage, commodity movements by barge were 79 percent below average. The major commodities with the largest volume of downriver shipments during the outage were wheat, forest products, crushed rock products and smelted products.

Around 10,500 tons were shipped upriver between December 10, 2010 and March 24, 2011 (Table A.6, Appendix A). Since over 608,000 tons are usually shipped upriver during the winter months, upriver shipments between Portland and The Dalles Lock and Dam were 98 percent below average during the extended lock outage. The major commodity with the largest volume of upriver shipments over the 15 week span was forest products.

Manufactured equipment and machinery were shipped in mass quantity during the month of February 2011. This surge in upriver shipments of this commodity is due to the U.S. Army Corps of Engineers' construction and assembly of lock gates and repairs. The Corps reported that during the month of February, two gate leaves constructed for The Dalles Lock and Dam originated in Portland and passed through Bonneville hence explaining the large movement of manufactured equipment and machinery during this month.

Pacific Northwest Wheat, December 2010 – March 2011

The original survey served as a benchmark for volumes, rates and modal choices for wheat elevators in the Pacific Northwest during times in which barge, rail and truck transportation are all available. This second survey allowed comparison of normal volumes, rates and modal choices for wheat elevators to those during the extended lock outage.

During this period, Northern Washington shipped the highest percentage of wheat in the Pacific Northwest, over 57 percent (Table 2.5). This represents a shift in volume shipped; Southern Washington, including the county of Whitman, normally ships the highest percentage of wheat from the Northwest, about 35 percent. However, Northern and Southern Washington wheat elevators together moved 61 percent of all shipments from the three states during the lock outage, compared to 69 percent during a typical time period.

Table 2.5 Wheat Tonnage Shipped by Survey Respondents, Dec 2010 - Mar 2011

Region	Number of Firms	Tonnage Shipped in Bushels	Percentage of Total Tonnage Shipped, Dec 2010 - Mar 2011	Typical Percentage of Total Tonnage Shipped, Dec - Mar
Eastern Oregon	5	9,681,700	27.3%	12.7%
Northern Idaho	5	2,428,000	6.8%	15.7%
Southern Idaho	3	1,620,000	4.6%	2.9%
Northern Washington	5	20,315,826	57.3%	34.0%
Southern Washington	8	1,433,200	4.0%	34.8%
Pacific Northwest	**26**	**35,478,726**	**100.0%**	**100.0%**

Source: Elevator Firm Survey (Washington, Oregon and Idaho) – Washington State University

Eastern Oregon firms experienced a decline in shipments during the lock outage of 20 percent when compared to a typical winter's movements. Northern Idaho suffered a decline in shipments of 86 percent during the lock outage, whereas Southern Idaho experienced a 32 percent decline in shipment volumes.

Most wheat firms in the Pacific Northwest moved the majority of their product, an average of 93 percent, by rail during the lock outage. However, Eastern Oregon and Southern Washington firms mostly employed trucking services to transport wheat from December 2010 to March

2010, about 40 to 75 percent, respectively (Table 2.6). Twenty percent of wheat coming from Eastern Oregon was shipped via truck-barge (Table 2.6). This was because of one wheat elevator's access to the Columbia River and Bonneville Lock and Dam to head to Portland. This lock was open 11 weeks during the 15 week outage.

Table 2.6 Wheat Shipped via Various Modes by Survey Respondents, Dec 2010 - Mar 2011

Region	Direct Truck to Final Market	Truck-Barge	Rail
Eastern Oregon	40.4%	20.0%	39.6%
Northern Idaho	2.0%	0.0%	98.0%
Southern Idaho	6.0%	0.0%	94.0%
Northern Washington	14.1%	0.0%	85.9%
Southern Washington	75.3%	0.0%	24.8%
Pacific Northwest	**27.6%**	**4.0%**	**68.5%**

Source: Elevator Firm Survey (Washington, Oregon and Idaho) – Washington State University

Shipping rates for truck and rail increased slightly in the Pacific Northwest during the lock outage. Additional costs, such as investment in storage expansion and shipping from alternative sources, were incurred by several firms in varying amounts. Railcars were unreliable for some elevators during the lock outage which led to unforeseen costs, delays and potentially lost business; the magnitude was uncertain.

Industrial, Regional and Institutional Impacts from the Extended Lock Outage

The authors conducted a broad survey and interviews concerning the activities of and impacts on the actors in the region, both state and regional, for the recent lock outage. These actors include carriers, shippers, associations and industries. The experiences of these entities are discussed below.

Wheat

This industry was impacted, especially in Southern Washington, by the extended lock outage despite careful and methodical planning since 2009 on the part of regional wheat commissions, U.S. Wheat Associates, exporters, elevators and producers. Although most firms were able to work around the lock outage without too much difficulty, some firms called the outage a "nightmare."

Despite the large amount of wheat shipped by rail in the Pacific Northwest, elevators and exporters were not particularly happy with the service. One elevator manager commented, that "rail performance was terrible. Cars were ten days early in December and over 30 days late by the end of February and continuing through March." Another manager echoed this thought: “We could not wait for the river to open as there was lots of grain that needed to be moved. Trains were backed up quite a ways and/or arrived late in Portland [during the lock outage].”

Total shipment volumes in the Pacific Northwest decreased by about 1.6 million bushels during the extended lock outage from previous winters. However, during the summer and fall of 2010, wheat producers experienced high wheat prices due to increased demand for wheat. This increase was partially the result of a ban on Russian wheat exports due to a massive drought in Eastern Europe. Wheat producers in the Pacific Northwest jumped at the opportunity to sell their wheat at historically high prices and therefore, an above average volume of wheat was shipped by barge from August to November. September 2010 shipments downriver were 65 percent above 2007-2009 averages. Due to high prices and the need to move around the lock outage, many wheat elevators took the opportunity to ship prior to the outage.

Petroleum: Gasoline, Jet Fuel and Kerosene; Distillate, Residual and Other Fuel Oils; and Lubricating Oils and Grease

According to the Oregon Department of Energy (OED), petroleum companies shipped more than half of their product by tanker truck during the lock outage. It was stated that tanker truck is far more economical and convenient than transporting the commodity by rail. Tanker trucks used two routes; fuel was transported from refineries in the Seattle area to Eastern Washington via Interstate 90, a major highway system running through the middle of the state, and by way of highways on both sides of the Columbia-Snake River from Portland to various towns in Eastern Washington and Oregon. The ODE representative also stated that transportation of fuels to Eastern Washington and Oregon was “smooth sailing” since shippers, carriers and the petroleum industry had ample time to plan ahead. In addition, there were no reported fuel shortages, price gouging or price hikes due to the lock outage.

Forest Products, Lumber, Logs and Woodchips

Various paper companies in the Pacific Northwest moved almost 58,000 tons of forest products from December 2010 to March 2011 by truck and rail; less than 15 percent of this volume moved by rail. Most of these paper firms shipped forest products to their original destination during the lock outage, mainly to the Portland and Vancouver, Washington areas. One paper firm stated that woodchip shipments were being brought in by five trucks per day over the 15 week period. However, not all forest products were transported from the typical origin of Lewiston, Idaho and Boardman, Oregon. One paper company trucked local logs and woodchips, from the Portland area, to their facility in order to mitigate transit time and costs. Additional costs were incurred during the extended lock outage including an increase in inventory costs, storage costs and transportation costs.

Barge Lines

Most barge companies temporarily laid off a significant number (from 35 percent to 67 percent) of their employees, including boat crews, in order to reduce costs. Some barge companies offered job sharing and reduced employees' work hours rather than lay off their entire staff. All of the barge lines were able to continue benefit packages for employees during the extended lock outage.

Rail Lines

In contrast to barge companies, which lost business for the majority of the lock outage, rail lines experienced an increase in cargo loads during the lock outage. Rail lines in the Pacific Northwest dealt with greater than normal volumes, additional products that would have moved by barge, increased crew numbers, additional days of operation and a few extra trains per week. Part of this experience included rail lines reaching out to industries that needed transportation during the outage and partnering with local ports to aid in the movement of products that would normally travel by barge.

Ports

The Port of Portland rewarded shippers for their continued support and patronage by subsidizing rail and truck transportation for industries that normally use barge to ship commodities to the Port. Port commissioners intended that this subsidy would encourage carriers and industries to continue business with Portland during and after the outage, instead of seeking commerce with other local ports. Indeed, no carriers or industry customers of the Port of Portland were lost to other local ports.

The Port of Portland set aside $800,000 to subsidize patrons' alternative transportation modes and only 48 percent of this total, or about $380,000 was used. This is evidence that most customers of the Port, both industries and carriers, either shipped goods prior to the lock outage or waited until the river was once again open to barge commodities.

Pacific Northwest Waterways Association (PNWA)

Activities and Impacts

- Main contact for the media regarding questions and concerns surrounding the extended lock closure
- Provided members and Columbia-Snake River stakeholders with updates and information concerning the lock outage
- Met with district and federal Congressional staff to emphasize the importance of the Columbia-Snake River System and provide rehabilitation updates
- Attended lock tours during the outage to provide information about the grain industries and barge community to tour participants

- Continued to work with the U.S. Wheat Associates to ensure buyers overseas of the importance and benefits of the extended lock outage

U.S. Army Corps of Engineers (USACE)

Activities and Impacts

- Hosted several teleconferences (on the first Tuesday of every month) for stakeholders discussing progress made, projects completed and plans for the future for each Columbia-Snake River lock
- Documented the progression in lock rehabilitation made during to the lock outage on the USACE website
- Made plans for potential disruptions during the lock outage including bad weather and unexpected delays in construction and traffic
- Announced delays and revisions in construction and opening dates via email, telephone and website postings
- Hosted several tours at various Columbia-Snake River locks inviting the public to view construction and rehabilitation and to emphasize the importance of major lock repairs to the Pacific Northwest economy and community

2.4 Return of Barge Traffic to the River, April – June 2011

The commodity movements in the three months following the extended lock outage reveal how shippers and carriers instantly responded to the reopening of the lock system. Three alternative options were available to move products with the absence of barge: 1) increase barge movements prior to December 2010, 2) ship products by truck and rail during the lock outage and/or 3) increase barge movements after March 2011. The third alternative is evident in the data discussed below.

The most notable characteristic is that the traffic has returned with major surges above past movement levels; this is especially true in movements downriver. Between April 2011 and June 2011 about five times more tonnage traveled downriver than upriver, compared to the typical three to one movement. Analyses for the last 30 years (see references) of Columbia-Snake River transportation found that three times more tonnage consistently traveled downriver than upriver. The fact that downriver traffic increased relative to upriver traffic during this three month period suggests that industries that ship products downriver were more impacted by the lock outage as these entities chose to heavily transport commodities after the lock outage rather than during. Also, monthly total tonnage traveling both downriver and upriver gradually decreased from high tonnages in April to mostly below average volumes in June. The downriver high in April was likely due to wheat elevators' commodity shipments following the lock outage as many managers chose to immediately ship wheat after the lock outage was complete and barge transportation was an option again.

Downriver Movements

A total of 2.4 million tons were shipped downriver between April and June 2011. The commodities with the largest volume of downriver shipments over the three month period were wheat, forest products, crushed rock products, iron ore products and vegetable products.

During this time period, wheat comprised 80 percent, or 1.9 million tons, of the total downriver 2.4 million tons (Table A.7, Appendix A). The second highest commodity by total tonnage was forest products which comprised 11 percent of the three month period's volume.

Upriver Movements

Around 514,000 tons were shipped upriver between April and June 2011. The commodities with the largest volume of upriver shipments over the three month span were diesel fuel, gasoline, landfill materials, fertilizer and crushed rock products.

The highest proportion of total upriver shipments, 43 percent or 219,000 tons of the total 514,000 tons, was distillate, residual and other fuel oils (Table A.8, Appendix A). The second highest proportion of total upriver shipments was gasoline, jet fuel and kerosene products, comprising 150,000 tons (about 29 percent) of the total upriver tonnage for April through June.

Total Movements

Major commodities in general moved in near and above average quantities on the Columbia-Snake River during the months of April through June 2011 in order to ship products that had been halted by extended lock outage. Those major commodities moving downriver from April to June 2011 that rose above average levels for at least two months include forest products and wheat. Those major commodities moving upriver that rose above average levels for at least two months during this time period include fertilizers and primary non-ferrous metallic products.

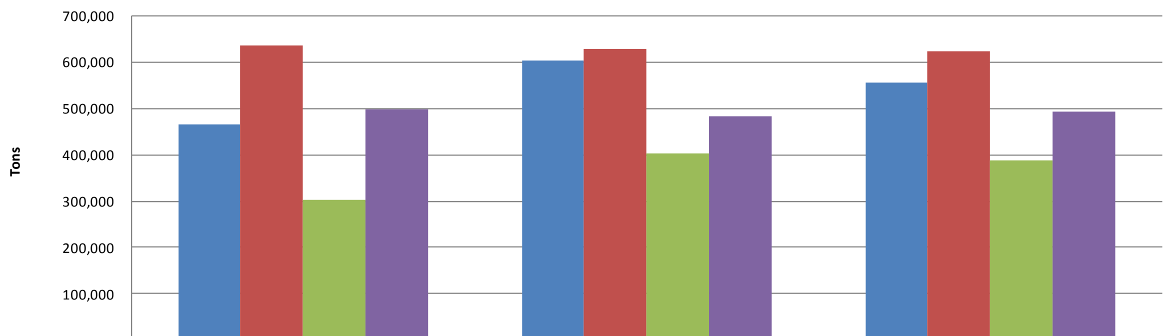
Pre and Post Lock Outage Barge Movements

Commodity movements prior to and after the extended lock outage were also examined as to determine whether industries were able to effectively reconfigure commodity shipments that would have shipped by barge during the extended lock outage. Historic monthly averages for the three months prior to and after the lock outage, September through November and April through June, respectively, are compared to the actual monthly tonnage for those months in 2010 and 2011.

The information presented in this section only examines downriver movements since shipments in the westward direction make up over 75 percent of annual waterborne shipments in both directions. In addition, monthly total tonnages and monthly wheat tonnages will be the only volumes examined in order to simplify discussion.

During the three months before the lock outage on the Columbia-Snake River, monthly total shipments downriver were significantly higher than corresponding historic averages. Likewise, total monthly downriver wheat shipments were significantly higher than their corresponding historic averages. September 2010 downriver shipments of wheat were a remarkable 65 percent above average (Figure 2.6). Shipments of wheat in October 2010 were 80,000 tons above average or an increase of 20 percent. Lastly, downriver wheat movements in November 2010 were 27 percent above average.

Fig. 2.6 Monthly Wheat and Total Tonnage Shipped Downriver Prior to the Extended Lock Outage, September - November



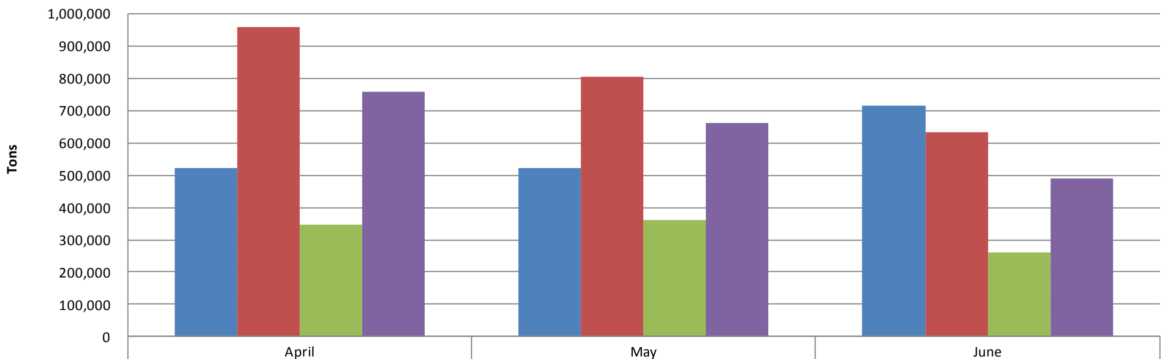
	September	October	November
Historical Total Average	464,998	604,044	555,725
Pre Outage Total	635,894	627,164	623,601
Historal Wheat Average	301,995	402,270	386,875
Pre Outage Wheat	498,162	482,300	491,955

Source: U.S. Army Corps of Engineers Monthly Lock Tonnage Reports

These significantly above average movements show that industries and shippers were prepared to ship their products prior to the lock outage as to avoid additional time and expenses to ship commodities by rail or truck during the lock outage. The wheat industry in particular shipped above average shipments prior to the lock outage; during this time wheat producers experienced high wheat prices due to increased demand for wheat. This increase was partially the result of a ban on Russian wheat exports due to a massive drought in Eastern Europe. Wheat producers in the Pacific Northwest jumped at the opportunity to sell their wheat at historically high prices. Barge transportation in this industry is the most economical mode of transportation and overseas buyers expected wheat shipments to be on time despite the transportation disruption; these three factors lead to many wheat elevators' decision to ship early and often prior to December 2010 as to build up inventories in exporters' houses and to satisfy wheat orders overseas.

After the lock outage, during the months of April through June 2011, monthly total shipments downriver were significantly above average for April and May, but below average for the month of June. Total monthly wheat movements made downriver, however, were above average for all three months following the lock outage. In April 2011, total wheat shipments moving downriver reached 758,000 tons and were a significant 118 percent above the 2007-2009 April average (Figure 2.7). Total wheat shipments during the month of May were 84 percent above average. Finally, June 2011 shipments of wheat downriver were also above average by 88 percent.

Fig. 2.7 Monthly Wheat and Total Tonnage Shipped Downriver After the Extended Lock Outage, April - June



	April	May	June
Historical Total Average	521,238	520,275	714,720
Post Outage Total	958,523	803,900	631,083
Historal Wheat Average	347,833	359,607	259,631
Post Outage Wheat	758,085	663,230	488,100

Source: U.S. Army Corps of Engineers Monthly Lock Tonnage Reports

This surge in shipments during the two months after the lock outage is evidence that industries waited to transport their goods until after the lock outage rather than during. This is likely due to the fact that barge transportation is more economical and more convenient for those industries that regularly use waterborne transportation. In addition, wheat shipments following the lock outage were notably larger than normal; this shows that the wheat industry chose to either ship prior to the lock outage or to transport goods after the lock outage ended. This is logical as barge transportation is substantially less expensive than rail and truck. During the lock outage, those elevators in the wheat industry that regularly use barge transported an insignificant volume by truck and rail; these volumes totaled about 45,500 tons (Interim Report #3). It appears that since the wheat industry prepared so well for the lock outage, elevator managers did not need to ship as much grain during the lock outage and were able to wait until the lock system reopened.

3. Economic Impacts of the Extended Lock Outage

The extended lock outage on the Columbia-Snake River caused many effects on shippers, river carriers, industries, ports and communities; the majority of these impacts were economic. The fiscal impacts for major commodity industries and ports that occurred during and because of the lock outage will be discussed below. Economic effects due the lock outage include transportation costs due to necessity of alternative modes of transportation, costs needed to set up alternative markets during the lock outage and fees charged to industries to load commodities onto railcars and/or trucks that were not equipped for those particular goods.

3.1 Economic Impacts of Commodity Industries

Major commodity types are discussed in detail in this section. However, exact rates and costs were only recorded and available for the commodities wheat, forest products and vegetable products. The rates and costs for the commodities gasoline, diesel, fertilizer, landfill material, crushed rock products, iron ore products, smelted products, grains other than wheat, processed grains and agricultural products were either proprietary information; not shipped during the lock outage due to lack of demand; not recorded by industry representatives; contracted costs in which the difference between rates for barge, truck and rail were indiscernible; and/or not available due to the competitive nature of the specific industry. Therefore these commodities will not be discussed in this chapter.

Wheat

This section describes the rates experienced and the transportation modes used prior to, during and after the lock outage for the wheat industry. Wheat industry firms of the Pacific Northwest were surveyed twice in order to determine rates, bushels shipped and modes used during a typical year and during the lock outage (Section 2). To complete the story and fill in the holes created by the surveys, wheat tonnage shipped from the Pacific Northwest recorded by the Federal Grain Inspection Service were also used to calculate total tonnages and shipping costs. Wheat firms' names and locations have been omitted due to the competitive nature of the industry.

In order to determine the transportation costs of the lock outage, a Shipping Cost Model (SMC) has been developed to calculate the total costs of wheat transportation during a typical year (SMC-Full) from August to July and the year including the lock outage (SCM-LO), August 2010 through July 2011. The models are used to calculate the change in costs brought about by a transportation disruption.

The model for the shipping costs of a typical year for the wheat industry:

$$SMC(Full) = \boldsymbol{A}_{1,3} * \boldsymbol{R}_{3,1} + \boldsymbol{B}_{1,3} * \boldsymbol{R}_{3,1} + \boldsymbol{C}_{1,3} * \boldsymbol{R}_{3,1} + e$$

where ***A*** is a 1 x 3 matrix of the tonnage of wheat shipped by truck, barge and rail during a typical autumn (August through November); ***B*** is a 1 x 3 matrix of the tonnage of wheat shipped by truck, barge and rail during a typical winter (December through March); ***C*** is a 1 x 3 matrix of the tonnage of wheat shipped by truck, barge and rail during a typical spring (April through July); ***R*** is a 3 x 1 matrix of the typical modal rates for truck, barge and rail; and e is the error term which includes additional costs not discussed.

The model for the shipping costs during the year in which the extended lock outage occurred: for the wheat industry

$$SMC(LO) = \boldsymbol{D}_{1,3} * \boldsymbol{X}_{3,1} + \boldsymbol{E}_{1,3} * \boldsymbol{X}_{3,1} + \boldsymbol{F}_{1,3} * \boldsymbol{X}_{3,1} + e$$

where ***D*** is a 1 x 3 matrix of the tonnage of wheat shipped by truck, barge and rail from August through November 2010; ***E*** is a 1 x 3 matrix of the tonnage of wheat shipped by truck, barge and rail from December 2010 through March 2011; ***F*** is a 1 x 3 matrix of the tonnage of wheat shipped by truck, barge and rail from April through July 2011; ***X*** is a 3 x 1 matrix of the actual modal rates experienced for truck, barge and rail from August 2010 to July 2011 and e is the error term which includes additional costs not discussed.

Matrices ***A***, ***B***, ***C***, ***D***, ***E*** and ***F*** take this form: $[y_{1,1} \quad y_{1,2} \quad y_{1,3}]$
where $y_{1,1}$ represents truck tonnage in bushels, $y_{1,2}$ represents barge bushels and $y_{1,3}$ represents rail bushels for the particular time period.

The matrix ***R*** and ***X*** takes this form: $\begin{bmatrix} w_{1,1} \\ w_{2,1} \\ w_{3,1} \end{bmatrix}$ in which rates are in terms of cents per bushel.

Note: the wheat industry shipped an unusually above average amount of grain during the year of the lock outage because of several factors: 1) a Russian drought and ban on wheat exports decreased the global supply of wheat and hence increased demand for U.S. wheat, 2) wheat prices reached historic highs prior to the lock outage encouraging wheat firms to supply a strong global demand and 3) wheat firms extensively planned for the lock outage by planning shipments primarily before or after the lock outage. **These reasons should be taken into account while reviewing the data presented below.**

In addition, recorded truck and rail tonnages prior to and after the lock outage were not available. Therefore, the authors used the data provided by the Federal Grain Inspection Service, modal averages and elevator wheat distribution to calculate the volume of tonnage shipped by truck and rail during the time periods prior to and after the lock outage. **This assumption should be taken into consideration when examining the data below.**

Before examining the costs incurred during the lock outage, the tonnage of wheat shipped during a typical year and during the year of the lock outage is described. In fact, 21.9 percent more tonnage traveled from August 2010 to July 2011 than during a typical year (Table 3.1); 85.4 million more bushels of wheat were shipped during the year of the lock outage when compared to a typical year. The increase in bushels shipped is mainly due to the Russian drought and wheat export ban that drove global wheat supply down and prices up. Pacific Northwest producers leaped at the chance to gain additional revenue from historic wheat prices and supply global markets which they typically did not. Bushels shipped during all three periods were above average by 21.9 percent. Since tonnage increased so drastically during the year of the lock outage, costs should be expected to be greatly above average as well.

Table 3.1 Total Annual Bushels for the Wheat Industry, August - July

Year	Time Period			Total Annual Bushels
	Aug - Nov	Dec - Mar	Apr - Jul	
Typical August - July	171,352,480	132,586,318	85,787,202	389,726,000
August 2010 - July 2011	208,906,375	161,644,157	104,588,468	475,139,000
Difference	**37,553,895**	**29,057,839**	**18,801,266**	**85,413,000**
Percentage Difference	**21.92%**	**21.92%**	**21.92%**	**21.92%**

Source: Elevator Firm Survey (Washington, Oregon and Idaho) – Washington State University

During a typical August through November time period, the wheat industry incurs total shipping costs of $82.6 million. Trucking costs amount to $5.5 million, barging costs $49.9 million and rail costs $27.2 million (Table 3.2). The average rate for truck transportation is $0.89 per bushel; the rate for barge is $0.52 per bushel and $0.63 per bushel for rail. Clearly, barge transportation is essential to the Pacific Northwest as typically 69 percent of shipments from August to November move by barge according to those firms surveyed (Table 3.2).

Note: blank cells in the rate columns of Tables 3.2 through 3.7 represent unrecorded data. In all cases, blank cells are not necessary as the particular firm does not ship wheat via that mode. For example, firm 6 in Table 3.2 does not have a recorded rate for truck, but also does not utilize truck during a typical autumn period and therefore a truck rate is unnecessary. For those cells that were necessary, the average is substituted in to calculate cost.

Table 3.2 Typical Rates and Costs for Wheat Shipments, August - November									
Firm	Truck Bushels	Barge Bushels	Rail Bushels	Typical Rates (Per Bushel)			Typical Total Cost, August - November		
				Truck	Barge	Rail	Truck	Barge	Rail
1	10,545	1,001,762	42,179	*$0.50*	*$0.29*	*$0.58*	$5,307.58	$293,850.12	$24,464.08
2	10,545	1,001,762	42,179	*$0.50*	*$0.29*	*$0.58*	$5,307.58	$293,850.12	$24,464.08
3	0	5,423,071	0	$0.70	$0.23	$0.60	$0.00	$1,247,306.38	$0.00
4	40,673	4,026,630	0	$0.46	$0.30	$0.66	$18,709.60	$1,207,989.11	$0.00
5	189,807	6,643,262	2,657,305	$0.35	$0.35	$0.48	$66,432.62	$2,325,141.78	$1,275,506.35
6	0	131,811	244,791		$1.05	$0.70	$0.00	$138,401.30	$171,353.99
7	0	2,741,664	1,476,280	$1.00	$0.51	$0.62	$0.00	$1,398,248.53	$915,293.91
8	0	6,063,295	0	$1.00	$0.35	$0.60	$0.00	$2,122,153.21	$0.00
9	42,368	8,431,181	0	$2.50	$0.40	$1.00	$105,919.36	$3,372,472.41	$0.00
10	29,526	2,804,933	118,102	*$1.50*	*$0.58*	*$0.73*	$44,288.41	$1,619,848.78	$86,214.78
11	2,937,497	0	979,166	$0.75	$0.80	$0.81	$2,203,122.68	$0.00	$793,124.17
12	45,192	135,577	723,076	*$0.71*	$1.28	$1.20	$31,860.54	$173,538.28	$867,691.39
13	361,538	903,845	542,307	$0.66	$0.51	$0.48	$238,615.13	$460,961.05	$260,307.42
14	2,006,536	704,999	2,711,536	$0.50	$0.56	$0.56	$1,003,268.17	$394,799.58	$1,518,459.94
15	349,487	174,743	8,212,940	*$0.52*	$0.49	$0.43	$180,568.19	$85,624.27	$3,531,564.23
16	800,355	545,697	2,291,925	$0.80	$0.54	$0.52	$640,283.94	$294,676.13	$1,191,801.25
17	112,981	112,981	2,033,652	*$0.52*	$0.58	$0.50	$58,373.34	$65,528.78	$1,016,825.85
18	723,076	13,738,447	21,692,285	$0.25	$0.70	$0.70	$180,769.04	$9,616,912.95	$15,184,599.40
19	26,362	2,504,404	105,449	*$1.22*	*$0.47*	*$0.55*	$32,161.83	$1,168,722.06	$58,348.23
20	143,169	4,629,134	0	*$1.22*	$0.31		$174,666.28	$1,435,031.41	$0.00
21	48,205	4,579,482	192,820	$1.36	$0.44	$0.41	$65,558.91	$2,014,972.24	$79,056.33
22	0	3,850,381	0		$1.00		$0.00	$3,850,380.56	$0.00
23	0	6,778,839	0		$0.40		$0.00	$2,711,535.61	$0.00
24	253,077	24,801,512	253,077	$1.50	$0.30	$0.60	$379,614.99	$7,440,453.71	$151,845.99
25	0	15,064,087	0	$0.80	$0.35	$0.65	$0.00	$5,272,430.35	$0.00
26	21,090	2,003,524	84,359	*$1.22*	*$0.47*	*$0.55*	$25,729.46	$934,977.65	$46,678.58
Total	**8,152,028**	**118,797,022**	**44,403,429**				**$5,460,557.64**	**$49,939,806.37**	**$27,197,599.96**

Source: Elevator Firm Survey (Washington, Oregon and Idaho) – Washington State University

From August through November 2010, four months prior to the extended lock outage, the wheat industry incurred total shipping costs of $100.7 million (Table 3.3). These total costs were $18.1 million, or 21.9 percent, more than the costs to ship wheat during a typical autumn period (Table 3.8). The increase in costs was driven by an increase in tonnage shipped and the shift of wheat shipments to before the lock outage began. When compared to a typical autumn period, tonnage shipped from August through November 2010 was above average by 37.6 million bushels or 21.9 percent (Table 3.1). Therefore shipping costs were also above average by the same percentage.

During the four months prior to the lock outage, trucking costs amounted to $6.7 million, barging costs reached $60.9 million and rail costs amounted to $33.2 million (Table 3.3). The rates for truck and rail transportation for all firms were the same as those during a typical year. The rates for barge were seven percent higher than during a typical autumn because barge lines taxed tonnage shipped prior to the lock outage to make up for lost business during the transportation disruption. During the four months prior to the lock outage, 69 percent of shipments moved by barge according to those firms surveyed.

Table 3.3 Rates and Costs for Wheat Shipments, August - November 2010									
Firm	Truck Bushels	Barge Bushels	Rail Bushels	Actual Rates (Per Bushel)			Total Cost, August - November		
				Truck	Barge	Rail	Truck	Barge	Rail
1	12,856	1,221,310	51,424	*$0.50*	*$0.31*	*$0.58*	$6,470.80	$383,328.36	$29,825.66
2	12,856	1,221,310	51,424	*$0.50*	*$0.29*	*$0.58*	$6,470.80	$358,250.80	$29,825.66
3	0	6,611,601	0	$0.70	$0.23	$0.60	$0.00	$1,520,668.13	$0.00
4	49,587	4,909,113	0	$0.46	$0.30	$0.66	$22,810.02	$1,472,734.02	$0.00
5	231,406	8,099,211	3,239,684	$0.35	$0.35	$0.48	$80,992.11	$2,834,723.73	$1,555,048.45
6	0	160,699	298,440		$1.05	$0.70	$0.00	$168,733.56	$208,908.21
7	0	3,342,531	1,799,825	$1.00	$0.51	$0.62	$0.00	$1,704,691.01	$1,115,891.25
8	0	7,392,137	0	$1.00	$0.35	$0.60	$0.00	$2,587,247.85	$0.00
9	51,653	10,278,973	0	$2.50	$0.40	$1.00	$129,132.82	$4,111,589.09	$0.00
10	35,996	3,419,667	143,986	*$1.50*	*$0.58*	*$0.73*	$53,994.74	$1,974,857.53	$105,109.76
11	3,581,284	0	1,193,761	$0.75	$0.80	$0.81	$2,685,962.72	$0.00	$966,946.58
12	55,097	165,290	881,547	*$0.71*	$1.28	$1.20	$38,843.15	$211,571.22	$1,057,856.09
13	440,773	1,101,933	661,160	$0.66	$0.51	$0.48	$290,910.42	$561,986.05	$317,356.83
14	2,446,292	859,508	3,305,800	$0.50	$0.56	$0.56	$1,223,146.10	$481,324.52	$1,851,248.15
15	426,081	213,040	10,012,902	*$0.52*	$0.49	$0.43	$220,141.81	$104,389.83	$4,305,547.74
16	975,762	665,292	2,794,228	$0.80	$0.54	$0.52	$780,609.64	$359,257.84	$1,452,998.39
17	137,742	137,742	2,479,350	*$0.52*	$0.58	$0.50	$71,166.53	$79,890.17	$1,239,675.10
18	881,547	16,749,388	26,446,402	$0.25	$0.70	$0.70	$220,386.68	$11,724,571.63	$18,512,481.52
19	32,140	3,053,274	128,559	*$1.22*	*$0.47*	*$0.55*	$39,210.46	$1,424,861.14	$71,135.92
20	174,546	5,643,662	0	*$1.22*	$0.31		$212,946.43	$1,749,535.29	$0.00
21	58,770	5,583,129	235,079	$1.36	$0.44	$0.41	$79,926.90	$2,456,576.91	$96,382.44
22	0	4,694,236	0		$1.00		$0.00	$4,694,236.39	$0.00
23	0	8,264,501	0		$0.40		$0.00	$3,305,800.27	$0.00
24	308,541	30,237,053	308,541	$1.50	$0.30	$0.60	$462,812.04	$9,071,115.95	$185,124.82
25	0	18,365,557	0	$0.80	$0.35	$0.65	$0.00	$6,427,944.97	$0.00
26	25,712	2,442,619	102,847	*$1.22*	*$0.47*	*$0.55*	$31,368.37	$1,139,888.91	$56,908.74
Total	**9,938,641**	**144,832,776**	**54,134,959**				**$6,657,302.56**	**$60,909,775.16**	**$33,158,271.32**

Source: Elevator Firm Survey (Washington, Oregon and Idaho) – Washington State University

Throughout a typical December through March time period, in which the lock outage would occur, wheat elevators surveyed incur total shipping costs of $63.2 million. Trucking costs amount to $3.7 million, barging costs $38.4 million and rail costs $21.1 million (Table 3.4). Again, barge transportation is essential to the Pacific Northwest as typically 69 percent of shipments from December to March move by barge according to those firms surveyed.

Table 3.4 Typical Rates and Costs for Wheat Shipments, December - March

Firm	Truck Bushels	Barge Bushels	Rail Bushels	Typical Rates (Per Bushel)			Typical Total Cost, December - March		
				Truck	Barge	Rail	Truck	Barge	Rail
1	10,545	1,001,762	42,179	*$0.50*	*$0.29*	*$0.58*	$5,307.58	$293,850.12	$24,464.08
2	10,545	1,001,762	42,179	*$0.50*	*$0.29*	*$0.58*	$5,307.58	$293,850.12	$24,464.08
3	0	4,338,457	0	$0.70	$0.23	$0.60	$0.00	$997,845.10	$0.00
4	54,231	5,368,841	0	$0.46	$0.30	$0.66	$24,946.13	$1,610,652.15	$0.00
5	132,865	4,650,284	1,860,113	$0.35	$0.35	$0.48	$46,502.84	$1,627,599.25	$892,854.44
6	0	105,449	195,833		$1.05	$0.70	$0.00	$110,721.04	$137,083.19
7	0	3,916,663	2,108,972	$1.00	$0.51	$0.62	$0.00	$1,997,497.90	$1,307,562.73
8	0	7,795,665	0	$1.00	$0.35	$0.60	$0.00	$2,728,482.70	$0.00
9	45,192	8,993,260	0	$2.50	$0.40	$1.00	$112,980.65	$3,597,303.91	$0.00
10	29,526	2,804,933	118,102	*$1.50*	*$0.58*	*$0.73*	$44,288.41	$1,619,848.78	$86,214.78
11	1,129,807	0	376,602	$0.75	$0.80	$0.81	$847,354.88	$0.00	$305,047.76
12	45,192	135,577	723,076	*$0.71*	$1.28	$1.20	$31,860.54	$173,538.28	$867,691.39
13	180,769	451,923	271,154	$0.66	$0.51	$0.48	$119,307.57	$230,480.53	$130,153.71
14	1,560,639	548,333	2,108,972	$0.50	$0.56	$0.56	$780,319.69	$307,066.34	$1,181,024.40
15	337,436	168,718	7,929,735	*$0.52*	$0.49	$0.43	$174,341.70	$82,671.71	$3,409,786.15
16	1,143,364	779,566	3,274,179	$0.80	$0.54	$0.52	$914,691.34	$420,965.90	$1,702,573.21
17	188,301	188,301	3,389,420	*$0.52*	$0.58	$0.50	$97,288.89	$109,214.63	$1,694,709.75
18	433,846	8,243,068	13,015,371	$0.25	$0.70	$0.70	$108,461.42	$5,770,147.77	$9,110,759.64
19	26,362	2,504,404	105,449	*$1.22*	*$0.47*	*$0.55*	$32,161.83	$1,168,722.06	$58,348.23
20	131,238	4,243,372	0	*$1.22*	$0.31		$160,110.75	$1,315,445.46	$0.00
21	48,205	4,579,482	192,820	$1.36	$0.44	$0.41	$65,558.91	$2,014,972.24	$79,056.33
22	0	2,464,244	0		$1.00		$0.00	$2,464,243.56	$0.00
23	0	4,519,226	0		$0.40		$0.00	$1,807,690.40	$0.00
24	72,308	7,086,146	72,308	$1.50	$0.30	$0.60	$108,461.42	$2,125,843.92	$43,384.57
25	0	13,181,076	0	$0.80	$0.35	$0.65	$0.00	$4,613,376.55	$0.00
26	21,090	2,003,524	84,359	*$1.22*	*$0.47*	*$0.55*	$25,729.46	$934,977.65	$46,678.58
Total	**5,601,460**	**91,074,034**	**35,910,824**				**$3,704,981.60**	**$38,417,008.06**	**$21,101,857.02**

Source: Elevator Firm Survey (Washington, Oregon and Idaho) – Washington State University

During the extended lock outage, wheat elevators surveyed incurred total shipping costs of $105.8 million (Table 3.5). These total costs were $42.6 million, or 67.4 percent, more than the costs to ship wheat during a typical winter period (Table 3.8). The increase in costs was driven by an increase in tonnage shipped due to global demand. Also, truck rates increased by four percent and rail rates increased by two percent, which contributes to the increase in shipping costs (Section 2). When compared to a typical winter period, tonnage shipped from December 2010 through March 2011 was above average by 29.1 million bushels or 21.9 percent (Table 3.1).

Trucking costs amounted to $49.2 million, barging costs were $9.5 million and rail costs amounted to $47.2 million during the lock outage (Table 3.5). Rail transportation was essential to the Pacific Northwest during the lock outage as 47 percent of shipments from December to March moved by rail according to those firms surveyed.

Note: Firm 27 is not an actual firm (Table 3.5). Tonnage for this firm includes wheat that was not accounted for in the survey but was included in the Ten Year Wheat Report by the Federal

Grain Inspection Service. Therefore, the authors added the tonnage and used average rates to determine cost.

Table 3.5 Rates and Costs for Wheat Shipments, December 2010 - March 2011									
Firm	**Truck Bushels**	**Barge Bushels**	**Rail Bushels**	**Actual Rates (Per Bushel)**			**Total Cost, December - March**		
				Truck	**Barge**	**Rail**	**Truck**	**Barge**	**Rail**
1	143,700	0	0	*$0.56*			$80,472.00	$0.00	$0.00
2	38,000	0	0	*$0.56*			$21,280.00	$0.00	$0.00
3	0	0	600,000	$0.80		$0.40	$0.00	$0.00	$240,000.00
4	0	6,400,000	0	$0.46	$0.30	$0.66	$0.00	$1,920,000.00	$0.00
5	50,000	0	2,450,000	$0.42		$0.55	$21,000.00	$0.00	$1,347,500.00
6	0	0	200,000			$0.70	$0.00	$0.00	$140,000.00
7	0	0	1,850,000	$1.00		$0.65	$0.00	$0.00	$1,202,500.00
8	0	0	100,000	$1.00		$0.60	$0.00	$0.00	$60,000.00
9	0	0	0	$2.50		$1.00	$0.00	$0.00	$0.00
10	22,240	0	255,760	*$1.50*		*$0.74*	$33,360.00	$0.00	$188,623.00
11	0	0	1,000,000	$0.75		$0.87	$0.00	$0.00	$870,000.00
12	9,600	0	310,400	*$0.76*		$1.30	$7,296.00	$0.00	$403,520.00
13	45,000	0	255,000	$0.76		$0.52	$34,200.00	$0.00	$132,600.00
14	2,002,000	0	1,638,000	$0.56		$0.60	$1,121,120.00	$0.00	$982,800.00
15	0	0	5,600,000			$0.43	$0.00	$0.00	$2,408,000.00
16	651,836	0	4,176,576	$0.15		$0.52	$97,775.34	$0.00	$2,171,819.72
17	34,948	0	1,712,466	*$0.54*		$0.50	$18,872.07	$0.00	$856,232.86
18	0	0	4,500,000	$0.25		$0.70	$0.00	$0.00	$3,150,000.00
19	0	0	0				$0.00	$0.00	$0.00
20	0	0	0				$0.00	$0.00	$0.00
21	150,000	0	0	$1.36		$0.41	$204,000.00	$0.00	$0.00
22	120,000	0	0	$1.34		$0.58	$160,800.00	$0.00	$0.00
23	0	0	0				$0.00	$0.00	$0.00
24	3,600	0	356,400	$1.85		$0.68	$6,660.00	$0.00	$242,352.00
25	0	0	0	$0.80		$0.65	$0.00	$0.00	$0.00
26	803,200	0	0	*$1.34*		*$0.58*	$1,076,288.00	$0.00	$0.00
27	50,466,172	25,233,086	50,466,172	*$0.92*	*$0.30*	*$0.65*	$46,284,689.43	$7,569,925.84	$32,772,972.59
Total	**54,540,296**	**31,633,086**	**75,470,774**				**$49,167,812.84**	**$9,489,925.84**	**$47,168,920.17**

Source: Elevator Firm Survey (Washington, Oregon and Idaho) – Washington State University

During a typical April through July time period, the wheat industry incurs total shipping costs of $40.5 million. Trucking costs amount to $1.9 million, barging costs $23.7 million and rail costs $14.8 million (Table 3.6). Again, barge transportation is essential to the Pacific Northwest as typically 65 percent of shipments from April to July move by barge according to those firms surveyed.

Table 3.6 Typical Rates and Costs for Wheat Shipments, April - July									
Firm	Truck Bushels	Barge Bushels	Rail Bushels	Typical Rates (Per Bushel)			TypicalTotal Cost, April - July		
				Truck	Barge	Rail	Truck	Barge	Rail
1	9,038	858,653	36,154	*$0.50*	*$0.29*	*$0.58*	$4,549.35	$251,871.53	$20,969.21
2	9,038	858,653	36,154	*$0.50*	*$0.29*	*$0.58*	$4,549.35	$251,871.53	$20,969.21
3	0	1,084,614	0	$0.70	$0.23	$0.60	$0.00	$249,461.28	$0.00
4	40,673	4,026,630	0	$0.46	$0.30	$0.66	$18,709.60	$1,207,989.11	$0.00
5	56,942	1,992,979	797,191	$0.35	$0.35	$0.48	$19,929.79	$697,542.53	$382,651.90
6	0	26,362	48,958		$1.05	$0.70	$0.00	$27,680.26	$34,270.80
7	0	1,174,999	632,692	$1.00	$0.51	$0.62	$0.00	$599,249.37	$392,268.82
8	0	3,464,740	0	$1.00	$0.35	$0.60	$0.00	$1,212,658.98	$0.00
9	25,421	5,058,709	0	$2.50	$0.40	$1.00	$63,551.62	$2,023,483.45	$0.00
10	25,308	2,404,228	101,231	*$1.50*	*$0.58*	*$0.73*	$37,961.50	$1,388,441.81	$73,898.38
11	451,923	0	150,641	$0.75	$0.80	$0.81	$338,941.95	$0.00	$122,019.10
12	22,596	67,788	361,538	*$0.71*	$1.28	$1.20	$15,930.27	$86,769.14	$433,845.70
13	60,256	150,641	90,385	$0.66	$0.51	$0.48	$39,769.19	$76,826.84	$43,384.57
14	891,794	313,333	1,205,127	$0.50	$0.56	$0.56	$445,896.97	$175,466.48	$674,871.08
15	518,205	259,102	12,177,808	*$0.52*	$0.49	$0.43	$267,739.03	$126,960.12	$5,236,457.31
16	343,009	233,870	982,254	$0.80	$0.54	$0.52	$274,407.40	$126,289.77	$510,771.96
17	75,320	75,320	1,355,768	*$0.52*	$0.58	$0.50	$38,915.56	$43,685.85	$677,883.90
18	289,230	5,495,379	8,676,914	$0.25	$0.70	$0.70	$72,307.62	$3,846,765.18	$6,073,839.76
19	22,596	2,146,632	90,385	*$1.22*	*$0.47*	*$0.55*	$27,567.28	$1,001,761.77	$50,012.77
20	123,284	3,986,198	0	*$1.22*	$0.31		$150,407.07	$1,235,721.49	$0.00
21	24,103	2,289,741	96,410	$1.36	$0.44	$0.41	$32,779.45	$1,007,486.12	$39,528.16
22	0	1,386,137	0		$1.00		$0.00	$1,386,137.00	$0.00
23	0	3,766,022	0		$0.40		$0.00	$1,506,408.67	$0.00
24	36,154	3,543,073	36,154	$1.50	$0.30	$0.60	$54,230.71	$1,062,921.96	$21,692.28
25	0	9,415,054	0	$0.80	$0.35	$0.65	$0.00	$3,295,268.97	$0.00
26	18,077	1,717,306	72,308	*$1.22*	*$0.47*	*$0.55*	$22,053.82	$801,409.41	$40,010.21
Total	**3,042,968**	**55,796,165**	**26,948,069**				**$1,930,197.53**	**$23,690,128.63**	**$14,849,345.14**

Source: Elevator Firm Survey (Washington, Oregon and Idaho) – Washington State University

From April to July 2011, four months after the extended lock outage, the wheat industry incurred total shipping costs of $49.3 million (Table 3.7). These total costs were $8.9 million, or 21.9 percent, more than the costs to ship wheat during a typical spring period and are partially due to the increased use of barge. This influx in tonnage and consequently use of barge transportation was because of industry and regional preparation for the lock outage. The option to barge wheat after the lock outage is evident in Table 3.7.

From April to July 2011, trucking costs amounted to an average $2.4 million, barging costs reached $28.9 million and rail costs amounted to an average $18.1 million (Table 3.7). The rates for all transportation modes were the same as those during a typical year. During the four months after the lock outage, 65 percent of shipments moved by barge according to those firms surveyed.

Table 3.7 Rates and Costs for Wheat Shipments, April - July 2011

Firm	Truck Bushels	Barge Bushels	Rail Bushels	Actual Rates (Per Bushel)			Total Cost, April - July		
				Truck	Barge	Rail	Truck	Barge	Rail
1	11,019	1,046,837	44,077	*$0.50*	*$0.29*	*$0.58*	$5,546.40	$307,072.11	$25,564.86
2	11,019	1,046,837	44,077	*$0.50*	*$0.29*	*$0.58*	$5,546.40	$307,072.11	$25,564.86
3	0	1,322,320	0	$0.70	$0.23	$0.60	$0.00	$304,133.63	$0.00
4	49,587	4,909,113	0	$0.46	$0.30	$0.66	$22,810.02	$1,472,734.02	$0.00
5	69,422	2,429,763	971,905	$0.35	$0.35	$0.48	$24,297.63	$850,417.12	$466,514.53
6	0	32,140	59,688		$1.05	$0.70	$0.00	$33,746.71	$41,781.64
7	0	1,432,513	771,353	$1.00	$0.51	$0.62	$0.00	$730,581.86	$478,239.11
8	0	4,224,078	0	$1.00	$0.35	$0.60	$0.00	$1,478,427.34	$0.00
9	30,992	6,167,384	0	$2.50	$0.40	$1.00	$77,479.69	$2,466,953.45	$0.00
10	30,854	2,931,143	123,417	*$1.50*	*$0.58*	*$0.73*	$46,281.20	$1,692,735.03	$90,094.08
11	550,967	0	183,656	$0.75	$0.80	$0.81	$413,225.03	$0.00	$148,761.01
12	27,548	82,645	440,773	*$0.71*	$1.28	$1.20	$19,421.58	$105,785.61	$528,928.04
13	73,462	183,656	110,193	$0.66	$0.51	$0.48	$48,485.07	$93,664.34	$52,892.80
14	1,087,241	382,004	1,469,245	$0.50	$0.56	$0.56	$543,620.49	$213,922.01	$822,776.96
15	631,775	315,888	14,846,716	*$0.52*	$0.49	$0.43	$326,417.17	$154,784.91	$6,384,088.02
16	418,184	285,125	1,197,526	$0.80	$0.54	$0.52	$334,546.99	$153,967.65	$622,713.60
17	91,828	91,828	1,652,900	*$0.52*	$0.58	$0.50	$47,444.36	$53,260.12	$826,450.07
18	352,619	6,699,755	10,578,561	$0.25	$0.70	$0.70	$88,154.67	$4,689,828.65	$7,404,992.61
19	27,548	2,617,092	110,193	*$1.22*	*$0.47*	*$0.55*	$33,608.97	$1,221,309.54	$60,973.65
20	150,304	4,859,820	0	*$1.22*	$0.31		$183,370.54	$1,506,544.28	$0.00
21	29,385	2,791,565	117,540	$1.36	$0.44	$0.41	$39,963.45	$1,228,288.46	$48,191.22
22	0	1,689,925	0		$1.00		$0.00	$1,689,925.10	$0.00
23	0	4,591,389	0		$0.40		$0.00	$1,836,555.71	$0.00
24	44,077	4,319,579	44,077	$1.50	$0.30	$0.60	$66,116.01	$1,295,873.71	$26,446.40
25	0	11,478,473	0	$0.80	$0.35	$0.65	$0.00	$4,017,465.61	$0.00
26	22,039	2,093,674	88,155	*$1.22*	*$0.47*	*$0.55*	$26,887.18	$977,047.64	$48,778.92
Total	**3,709,870**	**68,024,545**	**32,854,053**				**$2,353,222.84**	**$28,882,096.72**	**$18,103,752.38**

Source: Elevator Firm Survey (Washington, Oregon and Idaho) – Washington State University

In addition to increases in rates and modal shifts, some wheat elevators incurred costs to improve or build storage facilities and to haul wheat tonnage to different markets. Most of the difference in costs due to a shift in markets is represented in the tables above. However, one firm "incurred added freight costs of approximately $450,000 to haul 4,500,000 bushels of wheat 20 miles further than we normally would have during that time of year." It was not reported and/or communicated if this dilemma occurred for other firms in the Pacific Northwest, but it is very likely.

As mentioned above, some firms spent funds to improve storage facilities. One firm in Eastern Washington incurred "staggering" costs to store wheat so that it could be shipped in the spring following the lock outage. "We invested $500,000 in improving our outside storage before the river closure and our expenses during the closure will approach that number due to a staggering loan balance at the bank, interest expense, a little lost business and other related expenses." Outside storage of wheat also faces weather risks and insect damage. Several elevators in the region expressed concern for the quality of their crops following the lock outage. These risks could result in additional costs; however, this information was not available at the time of this writing.

The total difference in the cost of wheat shipments during a typical year and the year including the extended lock outage (August 2010 through July 2011) is presented in the table below. Total costs for transportation of wheat would be $186.3 million during a typical year and were $255.9 million during the year of the lock outage (Table 3.8). Therefore, wheat shipment costs during the year of the lock outage were 37.4 percent more than during a typical year. Costs increased the most during the December 2010 to March 2011 time period; shipping costs increased by 67.4 percent during this time period (Table 3.8).

However, because a typical year of wheat shipments is drastically different than the year of the lock outage, cents per bushel for each year has been calculated to show the actual difference in costs. During a typical year, wheat costs $0.48 per bushel to transport compared to $0.54 per bushel during the lock outage. Consequently, the cost of wheat transportation per bushel rose by six cents or only 12.7 percent during the year of the lock outage (Table 3.8). Calculating cost per bushel allows the author to erase the influence of the large export year of 2010-2011.

Again, an increase in annual tonnage shipped, the Russian drought and ban on wheat exports, lack of global wheat supply, historic wheat prices, an increase in modal rates and a need to shift modes during the lock outage contributed to the increase of shipping costs during the extended lock outage.

Table 3.8 Total Shipping Costs for the Wheat Industry, August - July

Year	Time Period			Total Cost	Cents per Bushel
	Aug - Nov	Dec - Mar	Apr - Jul		
Typical August - July	$82,597,963.97	$63,223,846.67	$40,469,671.30	$186,291,481.94	$0.48
August 2010 - July 2011	$100,725,349.03	$105,826,658.85	$49,339,071.94	$255,891,079.82	$0.54
Difference	**$18,127,385.07**	**$42,602,812.17**	**$8,869,400.64**	**$69,599,597.88**	**$0.06**
Percentage Difference	**21.95%**	**67.38%**	**21.92%**	**37.36%**	**12.67%**

Source: Elevator Firm Survey (Washington, Oregon and Idaho) – Washington State University

Forest Products (Lumber, Logs and Woodchips)

During the extended lock outage, rates for transportation of forest products increased slightly and the actual mode of shipment changed from barge to truck. This shift in shipment mode increased overall transportation rates as barge is generally the least expensive shipment mode. Before examining the costs incurred during the lock outage, forest product tonnage shipped during a typical year and during the year of the lock outage is described. In fact, 9.1 percent more tonnage traveled from August 2010 to July 2011 than during a typical year (Table 3.9). The increase in tonnage shipped is mainly due to increase in demand; tonnage shipped from August to November 2010 increased by over 50 percent and from April to July 2011 by 35 percent when compared to the averages (Table 3.9). Since tonnage increased during the year of the lock outage, costs should be expected to be above average as well.

Table 3.9 Total Annual Tonnage Shipped by the Forestry Industry, August - July				
Year	**Time Period**			**Total Annual Bushels**
	Aug - Nov	**Dec - Mar**	**Apr - Jul**	
Typical August - July	201,497	169,067	195,177	565,741
August 2010 - July 2011	303,985	50,200	262,782	616,967
Difference	**102,488**	**-118,867**	**67,605**	**51,227**
Percentage Difference	**50.86%**	**-70.31%**	**34.64%**	**9.05%**

Source: U.S. Army Corps of Engineers Monthly Lock Tonnage Reports and Industry and shipping interviews, Washington State University

Note: A total of five forestry firms in the Pacific Northwest were surveyed. One firm has been omitted from the data below because the Port of Portland subsidized their increased costs due to the transportation shift of forest products from barge to rail during the lock outage (Section 2). Therefore, no additional economic impacts were experienced by this firm. Including the data from this firm would not add to the discussion below. The firms surveyed represent the majority of the industry.

The same SCM models were used to calculate the forestry industry's costs due to the lock outage.

During a typical autumn time period (August to November), forest products travel by barge and total about 201,500 tons (Table 3.10). The barge rate during a normal year is $5.14 per ton. Therefore, from August to November, transportation costs for barged forest products generally equal $1 million. However, throughout the four months prior to the extended lock outage, barge rates increased by seven percent due to Tidewater Barge Line's business interruption surcharge. Therefore, barge rates were $5.50 per ton prior to the lock outage. About 304,000 tons traveled downriver to Portland during this time at a total cost of $1.7 million, $636,000 more than during a typical autumn (Table 3.10); that is an increase in transportation costs of more than 61 percent.

Throughout a normal winter time period, from December to March, the forestry industry ships 169,000 tons downriver at a barge rate of $5.14 per ton. That amounts to an average cost of $869,000 from December to March (Table 3.10). During the actual extended lock outage from December 2010 through March 2011, the forestry industry was forced to use truck transportation. The truck rate experienced by the firms interviewed was $27.50 per ton; this rate was four times the cost to barge this commodity. Since firms trucked over 50,000 tons of forest products during this time period, the cost of transportation was $1.4 million (Table 3.10). The difference between transportation costs of this commodity during a normal winter and during the lock outage was an increase of $511,500 or almost 59 percent.

During a typical spring time period (April to July), forest products are barged downriver at a rate of $5.14 per ton (Table 3.10). Since 195,000 tons usually travel downriver during these months, total costs amount to a little over $1 million. However, after the lock outage, a surge of forest products were sent downriver to market. More than 262,500 tons were barged during this time period at a cost of $5.50 per ton. Total transportation costs reached $1.5 million (Table 3.10). Due to the surge in tonnage and consequent increase in cost, money spent on transportation of forest products rose $442,000 or 44 percent during the four months after the lock outage.

The total annual cost for the transportation of forest products barged downriver is typically $2.9 million. When compared to the total cost of the year of the lock outage, $4.5 million, transportation costs increased by $1.6 million or 55 percent due to the extended lock outage for the forestry industry (Table 3.10).

Note: the difference in costs between transporting forest products prior to and during the lock outage are due to *a difference in mode and a slight increase in barging rates*.

Table 3.10 Rates (per Ton) and Costs for Shipment of Forest Products Due to the Lock Outage

	Aug - Nov	Dec - Mar	Apr - Jul	Total Cost
Typical Tonnage	*201,497*	*169,067*	*195,177*	
Typical Barge Rate	*$5.14*	*$5.14*	*$5.14*	
Typical Cost	*$1,035,694.58*	*$869,001.81*	*$1,003,209.78*	*$2,907,906.17*
Actual Tonnage	303,985	50,200	262,782	
Actual Rates (Barge and Truck)	$5.50	$27.50	$5.50	
Actual Cost	$1,671,917.50	$1,380,500.00	$1,445,301.00	$4,497,718.50
Cost Difference	**$636,222.92**	**$511,498.19**	**$442,091.22**	**$1,589,812.33**
Percentage Difference	**61.43%**	**58.86%**	**44.07%**	**54.67%**

Source: Industry and shipping interviews, Washington State University
Red text represents truck rates rather than barge rates.

Vegetable Products

Prior to the lock outage, the agricultural firms surveyed, mostly producers of peas, lentils and beans, shipped their products solely by barge. During the lock outage, rates for transportation of agricultural products increased slightly and the actual mode of shipment changed from barge to truck and rail. This shift in shipment mode increased transportation rates as barge is generally the least expensive shipment mode.

Before examining the costs incurred during the lock outage, vegetable product tonnage shipped during a typical year and during the year of the lock outage is described. In fact, 20.4 percent less tonnage traveled from August 2010 to July 2011 than during a typical year (Table 3.11). The overall decrease in tonnage shipped is mainly due to major decreases in shipments during and after the lock outage; tonnage shipped from December 2010 to March 2011 decreased by almost 60 percent and from April to July 2011 by 33 percent when compared to the averages. Since tonnage decreased during the year of the lock outage, costs should be expected to be below average as well.

Table 3.11 Total Annual Tonnage Shipped by the Vegetable Industry, August - July				
Year	**Time Period**			**Total Annual Bushels**
	Aug - Nov	**Dec - Mar**	**Apr - Jul**	
Typical August - July	33,427	28,410	29,967	91,804
August 2010 - July 2011	41,393	11,558	20,117	73,068
Difference	**7,966**	**-16,852**	**-9,850**	**-18,736**
Percentage Difference	**23.83%**	**-59.32%**	**-32.87%**	**-20.41%**

Source: U.S. Army Corps of Engineers Monthly Lock Tonnage Reports and Industry and shipping interviews, Washington State University

Note: A total of ten agricultural firms in the Pacific Northwest were surveyed. Five firms have been omitted from the data below as the Port of Portland subsidized their increased costs due to the transportation shift of agricultural products from barge to truck and rail during the lock outage. Therefore, no additional economic impacts were experienced by these firms. Including the data from this firm would not add to the discussion below. The firms surveyed represent the majority of the industry.

The same SCM models were used to calculate the vegetable industry's costs due to the lock outage.

During a typical autumn time period (August to November), vegetable products travel by barge and total about 33,500 tons (Table 3.12). The barge rate during an average year is $22.67 per ton. Therefore, from August to November, transportation costs for barged vegetable products equal $758,000. However, throughout the four months prior to the extended lock outage, barge rates increased by seven percent due to Tidewater Barge Line's business interruption surcharge. Therefore, barge rates were $24.26 per ton prior to the lock outage. About 41,500 tons traveled downriver to Portland during this time at a total cost of $1 million, $246,000 more than during a typical autumn (Table 3.12); that is an increase in transportation costs of more than 32 percent.

Throughout a normal winter time period, from December to March, the vegetable industry ships 28,500 tons downriver at a barge rate of $22.67 per ton. That amounts to an average cost of $644,000 from December to March (Table 3.12). During the actual extended lock outage from December 2010 through March 2011, the vegetable industry was forced to use truck and rail transportation. The average truck and rail rate experienced by the firms interviewed was $40.83 per ton; this rate was almost two times the cost of barge. Since firms trucked and railed over 11,500 tons of vegetable products during this time period, the cost of transportation was $472,000 (Table 3.12). The difference between transportation costs of this commodity during a normal winter and during the lock outage was a decrease of $172,000 or 27 percent.

During a typical spring time period (April to July), vegetable products are barged downriver at a rate of $22.67 per ton (Table 3.12). Since 30,000 tons usually travel downriver during these months, total costs amount to a little over $679,000. After the lock outage, more than 20,000 tons were barged during this time period at a cost of $24.26 per ton. Total transportation costs reached $488,000 (Table 3.12). Due to the low tonnage, money spent on transportation of vegetable products fell by $191,000 or by 28 percent during the four months after the lock outage.

The total cost for the transportation of vegetable products barged downriver is typically $2.08 million. When compared to the total cost of the year of the lock outage, $1.96 million, transportation costs decreased by $117,000 or 6 percent due to the extended lock outage for the vegetable industry (Table 3.12). This decrease in costs is again due to a general decrease in tonnage shipped during the year of the lock outage.

Table 3.12 Rates (per Ton) and Costs for Shipment of Vegetable Products Due to the Lock Outage

	Aug - Nov	**Dec - Mar**	**Apr - Jul**	**Total Cost**
Typical Tonnage	*33,427*	*28,410*	*29,967*	
Typical Barge Rate	*$22.67*	*$22.67*	*$22.67*	
Typical Cost	*$757,790.09*	*$644,054.70*	*$679,351.89*	*$2,081,196.68*
Actual Tonnage	41,393	11,558	20,117	
Actual Rates (Barge and Truck)	$24.26	$40.83	$24.26	
Actual Cost	$1,004,065.86	$471,913.14	$488,038.42	$1,964,017.42
Cost Difference	**$246,275.77**	**-$172,141.56**	**-$191,313.47**	**-$117,179.26**
Percentage Difference	**32.50%**	**-26.73%**	**-28.16%**	**-5.63%**

Source: Industry and shipping interviews, Washington State University
Red text represents truck rates rather than barge rates.

Port of Portland

As mentioned in Section 2, the Port of Portland set aside $800,000 to subsidize patrons' alternative transportation modes during the lock outage; only 48 percent of this total, or about $380,000 was used for continued transportation. This economic impact on the Port of Portland allowed industries to continue shipments without the additional pecuniary burden.

3.2 Qualitative Economic Impacts of the Extended Lock Outage

Due to the competitive and/or proprietary nature of most major commodity industries, information regarding transportation and additional costs was unavailable. However, many representatives interviewed had comments regarding general impacts of the lock outage. A few qualitative comments regarding the pecuniary effects of the disruption in barge transportation are listed below.

- "We pay [the steamship line] one price from Lewiston, Idaho to Europe. The price was worked out with [the steamship line] and the rail, so we have no idea if the costs were any different from barge."

- "The one problem we had was that the rail only took a total of 52,900 pounds per container. So if the empty container weighed more than 4,900 pounds, we could not load the full 48,000 pounds that our customers are used to getting. The buyers overseas could not understand why our weights per container were not the same as they used to be. We were charged for short weights and it was a nightmare with our buyers overseas."
- "We had no lay-offs, and any changes in price that could be directly related to the river closure would be difficult to quantify. Had we faced an early spring season, the impact would have been much more significant."

3.3 Total Economic Impacts of the Extended Lock Outage

The total economic cost of the year of the extended lock outage was dramatically above average; shipping costs for industries and ports were 38.4 percent more than the typical annual cost of transportation (Table 3.13). However, five factors should be kept in mind while reviewing the economic impacts of the lock outage: 1) industries, shippers, government departments, ports and communities extensively planned for the lock outage by scheduling shipments primarily before or after the lock outage, 2) wheat prices reached historic highs prior to the lock outage encouraging wheat firms to supply a strong global wheat demand 3) the global and national economies were and are still recovering from a significant recession which has slowed some demand and commodity shipments in general, 4) river flows following the lock outage reached record highs due to heavy snow and rainfall during the winter of 2010-2011 which hindered prompt barge shipments and therefore hindered high waterborne tonnage months, and 5) many industries' shipment information is proprietary or unavailable due to the competitive nature of the business. All of these factors contributed to the economic impact of the extended lock outage.

Although many industries' information regarding the lock outage and shipments were unavailable, the data provided and the qualitative comments of shippers and industry representatives give the reader a general sense of the effects of the disruption in transportation.

For the data available, the wheat industry experienced a 37.9 percent increase in shipping and storage costs (Table 3.13). Also, wheat transportation costs per bushel rose from $0.48 per bushel to $0.54 per bushel or increased by 12.7 percent (Table 3.8); calculating cost per bushel gets rid of the influence of the large export year of August 2010 to July 2011.

The forestry industry experienced a huge increase in shipping costs during the year of the lock outage; costs increased by $1.6 million or 54.7 percent. This increase was in part due to an increase in demand and a dramatic difference between barge and truck rates for forest products. The vegetable industry's shipping costs decreased by 5.6 percent or $117,000 due to lack of demand and unreported data (Table 3.13). Finally, the Port of Portland spent $380,000 to subsidize customers' shipping costs during the lock outage in order to maintain their client base. Therefore, total costs for these industries increased by 38.4 percent during the year of the lock outage, mainly due to the wheat industry.

Table 3.13 Total Transportation and Additional Costs Due to the Lock Outage

Industry/Port	Typical Annual Cost	Actual Cost for 2010-2011	Difference	Percentage Difference
Wheat	$186,291,481.94	$255,891,079.82	$70,549,597.88	37.87%
Wheat Storage, etc.	-	$950,000.00	$950,000.00	
Forest Products	$2,907,906.17	$4,497,718.50	$1,589,812.33	54.67%
Vegetable Products	$2,081,196.68	$1,964,017.42	-$117,179.26	-5.63%
Port of Portland Subsidy	-	$380,000.00	$380,000.00	
Total	**$191,280,584.79**	**$263,682,815.74**	**$73,352,230.95**	**38.35%**

4. Environmental Impacts of the Extended Lock Outage

Not only did the extended lock outage impact shippers, carriers and industries logistically and economically, but also affected the environment by rerouting commodity shipments to alternative modes of transportation and infrastructures. Transportation of freight involves the use of fuel and the production of diesel engine emissions. Most commodities that travel up and downriver on the Columbia-Snake, especially wheat, are dependent on all modes of freight transportation, not just barge. The disruption of barge transportation during the extended lock outage during the winter of 2010-2011 forced commodity industries to rely more heavily on rail and truck transportation, which are energy intense and are sources of noxious emissions. This section discusses the environmental impacts of the lock outage, including the increased energy consumption and additional emissions produced during the halt in river transportation.

4.1 Review of Literature

A review of the energy intensity literature provides information regarding the trends in energy consumption of various modes over time and specifies energy intensity coefficients for calculation. After reviewing various studies regarding energy usage for freight transportation, it was discovered that more accurate information regarding energy use for passenger vehicles, light trucks (including vans) and air travel is available than for that of heavy truck, barge and rail. It was also revealed that consumption of energy for truck, barge and rail has decreased since the 1970s. A key source of information for freight transportation is the Transportation Energy Data Book: Edition 29 produced by Oak Ridge National Laboratory and the U.S. Department of Energy.

All information regarding energy consumption for freight transportation should be handled with great care. Kolb and Wacker (1995) advise that using average data can be misleading as every cargo shipment is unique in weight, mode, vehicle, route and weather conditions. Therefore, a truly analogous energy intensity coefficient is impossible to calculate and coefficients should be calculated for each individual shipment with its unique characteristics.

Various truck characteristics also present an issue in calculating truck energy consumption. Two types of trucks are generally used to haul various commodities in the Pacific Northwest: single unit, 3 axle trucks and combination tractor and trailer, 5 axle trucks. Following the methodology of a similar study by Lee and Casavant (1998), the authors rely on average energy intensity and emissions coefficients.

To calculate rail energy consumption and emissions produced, factors for Class I railroads are used. The literature includes information for Class I rail lines, but not for branch lines transporting commodities to mainlines. Although some commodities traveled on branch rail lines for all or part of its shipment, it will be assumed that Class I and branch line locomotive qualities are similar in terms of energy usage and emission production.

Emissions data for tugboats, which propel barges up and downriver on the Columbia-Snake River, are used from a study of Californian marine vessel emissions by the Acurex Environmental Corporation. This study uses an aggregate factor for emissions calculations, including data for several tugboats similar to those used on the Columbia-Snake River. Although it is risky and inaccurate to use this information in this fashion, data on individual tug trips is proprietary and unavailable to the public, so analysis requires this generalization.

Energy Intensity Literature

The most recent and comprehensive studies on freight transportation energy use was developed by Green (1996). Energy intensities reported by Greene are based on data from 1992 for barge transportation and on data from 1993 for rail and truck. The mode truck is defined as all freight trucks including 3 to 7 axle tractors and trailers.

Truck energy intensity coefficients in Greene's study are presented in terms of Btu[2] per vehicle-mile. As rail and barge are reported in terms of Btu per ton-mile, the authors calculated the truck coefficient into Btu per ton-miles. Greene's Btu per ton-mile calculation assumes that a typical truck (5 axle tractor and trailer) can carry a total of 40 tons including the vehicle itself. Therefore, the following calculation was developed:

$$\frac{\text{Btu per Vehicle-Mile}}{\text{Tons per Vehicle}} = \text{Btu per Ton-Mile}$$

$$\frac{22{,}322}{40} = 558$$

Table 4.1 Energy Intensity Coefficients for Data Compiled by Greene

Mode	Btu per Ton-Mile
Truck	558
Rail	344
Barge	398

Source: Greene, 1996

The most recently updated energy intensity data for freight transportation modes are from the Transportation Energy Data Book: Edition 29, produced by the Oak Ridge National Laboratory and the U.S. Department of Energy. These energy consumption coefficients are used in this report. The data from 1970 to 2008 are summarized in the following table. The most recent estimates, those from 2008, will be used in this section to calculate energy usage.

[2] A Btu, or British thermal unit, is a basic measure of heat energy. One BTU is the amount of energy needed to heat one pound of water one degree Fahrenheit.

Table 4.2 Energy Intensity Coefficients for Truck, Rail and Barge, 1970 - 2008 (Btu per Ton-Mile)			
Year	**Truck**	**Rail**	**Barge**
1970	624	691	545
1971	592	717	506
1972	584	714	522
1973	581	677	576
1974	564	681	483
1975	550	687	549
1976	566	680	468
1977	567	669	458
1978	569	641	383
1979	576	618	436
1980	559	597	358
1981	566	572	360
1982	568	553	310
1983	574	525	286
1984	572	510	346
1985	578	497	446
1986	578	486	463
1987	577	456	414
1988	586	443	373
1989	571	437	423
1990	562	420	387
1991	548	391	386
1992	553	393	398
1993	554	389	389
1994	555	388	369
1995	551	372	374
1996	553	368	412
1997	534	370	415
1998	538	365	435
1999	572	363	457
2000	586	352	473
2001	576	346	460
2002	587	345	470
2003	562	344	418
2004	514	341	510
2005	572	337	515
2006	584	330	571
2007	581	320	590
2008	**552**	**305**	**418**

Source: Davis, 2010

Table 4.3 Percent Changes in Energy Intensity Coefficients for Truck, Rail and Barge, 1970 - 2008		
Mode	**Period**	**Percent Change**
Truck	1970 - 2008	-11.55%
	1998 - 2008	2.61%
Rail	1970 - 2008	-55.86%
	1998 - 2008	-16.44%
Barge	1970 - 2008	-23.30%
	1998 - 2008	-3.91%

Source: Davis, 2010

As evident by the table above, energy consumption in general has decreased since 1970 for all modes. Truck energy usage decreased by 11.6 percent from 1970 to 2008, which is a small decline in fuel consumption when compared to rail (55.9 percent) and barge (23.3 percent). However, from 1998 to 2008, energy usage for truck has increased by 2.6 percent. This is likely due to smaller container loads per truck in recent years. Rail energy intensity has decreased drastically, by 55.9 percent, over the past 38 years. Greene claims that this is because of increased cargo loads per railcar and improvements in railroad technology. Even in recent years, from 1998 to 2008, rail energy usage fell by 16.4 percent. Finally barge energy intensity decreased by 23.3 percent from 1970 to 2008 and by 3.9 percent from 1998 to 2008.

Freight Emissions Literature

Emissions from diesel engines in freight transportation are typically divided into five components: Nitrous Oxides (NOx), Hydrocarbons (HC), Carbon Monoxide (CO), Particulate Matter (PM) and Sulfur Oxides (SOx). Just like energy intensity coefficients, emissions production estimates differ by source. Kolb and Wacker highlighted the fact that emission coefficients are even more sensitive to the unique factors of individual trips. Average estimates for emissions produced are used in this study as information regarding exact transportation conditions, vehicle characteristics and speeds was unavailable. Emissions production coefficients are expressed in pounds of emission component per 1,000 gallons of diesel fuel.

Following the methodology of a study by Lee and Casavant (1998) and Technical Highlights: Emission Factors for Locomotives, the truck, rail and barge emission factors in the tables below are used in this study to calculate emissions produced.

Table 4.4 Emissions Coefficients for Truck, Rail and Barge (Pounds per 1,000 Gallons of Diesel Fuel)					
Mode	**HC**	**CO**	**NOx**	**PM**	**SOx**
	Hydrocarbons	**Carbon Monoxide**	**Nitrous Oxides**	**Particulate Matter**	**Sulfur Oxides**
Truck	212	23	93	15	6
Rail	22	59	596	15	36
Barge	19	57	419	9	75

Source: Lee and Casavant, 1998 and EPA, 2009

4.2 Ton-Miles for Major Commodities, August 2010 – July 2011

In order to determine the energy used and emissions produced prior to, during and after the lock outage, ton-miles traveled for each commodity and mode are necessary for calculation. The major commodity ton-miles traveled during a typical year and during the year of the lock outage are described below. However, exact tonnage and ton-miles were only recorded and available for the commodities gasoline, diesel fuels, fertilizer, forest products, iron ore products, wheat, vegetable products, other agricultural products and landfill material. Crushed rock products, smelted products, grains other than wheat and processed grains were either not shipped during the lock outage due to lack of demand, not recorded by industry representatives, not available due to the competitive nature of the specific industry and/or not able to be traced during the lock outage and therefore will not be discussed in this section.

Note: All ton-miles are for commodities that typically travel by barge. However, all wheat produced in and shipped from the Pacific Northwest is also included. This data is from surveys conducted for the Pacific Northwest wheat industry and from the Federal Grain Inspection Service. Also, miles traveled for each commodity shipped in the Pacific Northwest was determined from evaluating tonnage distribution for all eight lock and dams from 2007 to 2009. The loading and unloading point for commodities was determined and then miles were calculated using Rand McNally's Mileage Calculator (www.randmcnally.com).

During a typical[3] year from August to July, 3.7 billion ton-miles are produced by major commodities in the Pacific Northwest (Table 4.5). Of the total annual ton-miles, 84.3 million are created by truck, 739.4 million by rail, and 2.9 billion by barge. Over three billion of those total ton-miles, or 83 percent, are produced by the wheat industry. Within the wheat industry, 84.3 million ton-miles are created by truck transportation, 739.4 million by rail, and 2.3 billion by barge (Table 4.5). Seventy-four percent of all ton-miles created from the transportation of wheat are done so by barge.

[3] A typical year is defined as the average of the past three (2007-2009) years. Tonnages have been averaged over the three year period to determine typical tonnages and ton-miles.

Table 4.5 Ton-Miles Produced during a Typical Year, August - July						
Commodity Type	**Tonnage**	**Average Miles Shipped**	**Truck Ton-Miles**	**Barge Ton-Miles**	**Rail Ton-Miles**	**Total Ton-Miles**
Gasoline	863,070	221.81	0	189,244,441	0	189,244,441
Diesel Fuels	1,012,506	221.81	0	224,580,974	0	224,580,974
Fertilizer	52,260	221.27	0	11,563,460	0	11,563,460
Forest Products	565,741	200.98	0	113,700,263	0	113,700,263
Iron Ore Products	81,834	218.00	0	17,839,703	0	17,839,703
Wheat	11,691,780	309.87	84,267,314	2,285,240,949	739,353,067	3,108,861,330
Vegetable Products	91,804	344.90	0	31,663,200	0	31,663,200
Other Agricultural Products	8,011	218.00	0	1,746,289	0	1,746,289
Landfill Material	278,743	166.50	0	46,410,626	0	46,410,626
Total	**14,645,747**		**84,267,314**	**2,921,989,904**	**739,353,067**	**3,745,610,285**

Source: Industry and shipping interviews, Washington State University

During the year of the extended lock outage, August 2010 through July 2011, 4.2 billion ton-miles were produced by major commodities that typically travel by barge (Table 4.6). Of the total ton-miles, 356.6 million were created by truck, 1.3 billion by rail, and 2.5 billion by barge. Almost 3.6 billion of those ton-miles, or 86 percent, were produced by the wheat industry. Within this industry during the year of the lock outage, 239.1 million ton-miles were created by truck transportation, 1.2 billion by rail, and 2.1 billion by barge (Table 4.6). Throughout the year of the lock outage, ton-miles created by truck drastically increased 272.3 million ton-miles or 323.2 percent. Barge ton-miles obviously decreased from August 2010 to July 2011, due to the interruption of barge transportation, by 407 million ton-miles or 13.9 percent. Rail ton-miles also increased by 560.4 million ton-miles or 75.8 percent (Tables 4.5 and 4.6).

Table 4.6 Ton-Miles Produced from August 2010 to July 2011						
Commodity Type	**Tonnage**	**Average Miles Shipped**	**Truck Ton-Miles**	**Barge Ton-Miles**	**Rail Ton-Miles**	**Total Ton-Miles**
Gasoline	569,423	221.81	38,116,589	84,469,216	16,061,499	138,647,304
Diesel Fuels	874,117	221.81	57,174,884	132,602,879	24,092,248	213,870,011
Fertilizer	54,228	221.27	0	11,667,125	327,000	11,994,125
Forest Products	788,580	215.00	9,990,975	124,617,780	2,787,654	137,396,409
Iron Ore Products	77,100	218.00	0	14,845,800	1,962,000	16,807,800
Wheat	14,254,170	309.87	239,089,582	2,099,661,526	1,247,703,692	3,586,454,801
Vegetable Products	74,420	322.36	925,018	21,214,799	3,191,685	25,331,502
Other Agricultural Products	25,296	234.51	1,743,501	921,704	3,655,940	6,321,145
Landfill Material	218,099	153.25	9,555,000	24,949,859	0	34,504,859
Total	**16,935,432**		**356,595,549**	**2,514,950,687**	**1,299,781,719**	**4,171,327,955**

Source: Industry and shipping interviews, Washington State University

When compared to the average from the last three years (2007-2009), the total annual ton-miles from August 2010 to July 2011 increased by 425.7 million ton-miles or by 11.4 percent (Table 4.7). The increase in ton-miles can be attributed to the general increase in tonnage, especially for the wheat industry, during the year of the lock outage.

Despite the overall increase in ton-miles, gasoline and diesel fuel ton-miles actually decreased by 26.7 percent and 4.8 percent, respectively, throughout the year of the lock outage (Table 4.7). Gasoline and diesel ton-miles likely decreased as petroleum companies used pipeline transportation and shifted to closer source points during the lock outage to avoid elevated shipping costs. Vegetable products and landfill material ton-miles also decreased from August 2010 to July 2011 by 20 percent and 25.7 percent, in that order. The largest increases in commodity ton-miles was in the agricultural products industry; ton-miles drastically increased during the year of the lock outage by 262 percent. Several causes of the overall increase in ton-miles are: 1) increase in tonnage shipped during the year of the lock outage due to increase demand and 2) increase in miles traveled as products came from alternative sources during the lock outage. Ton-miles for wheat also increased during the year of the lock outage by 15.4 percent. This is mostly due to the large global demand for wheat during 2010 and 2011.

Table 4.7 Difference in Ton-Miles Produced Due to the Extended Lock Outage

Commodity Type	Typical Annual Total Ton-Miles	2010-2011 Total Ton-Miles	Difference	Percentage Difference
Gasoline	189,244,441	138,647,304	-50,597,137	-26.74%
Diesel Fuels	224,580,974	213,870,011	-10,710,963	-4.77%
Fertilizer	11,563,460	11,994,125	430,665	3.72%
Forest Products	113,700,263	137,396,409	23,696,146	20.84%
Iron Ore Products	17,839,703	16,807,800	-1,031,903	-5.78%
Wheat	3,108,861,330	3,586,454,801	477,593,470	15.36%
Vegetable Products	31,663,200	25,331,502	-6,331,697	-20.00%
Other Agricultural Products	1,746,289	6,321,145	4,574,856	261.98%
Landfill Material	46,410,626	34,504,859	-11,905,768	-25.65%
Total	**3,745,610,285**	**4,171,327,955**	**425,717,669**	**11.37%**

Source: Industry and shipping interviews, Washington State University

4.3 Energy Intensity Model

The energy consumption results in this section are for the nine major commodities discussed above during a typical year and the year of the extended lock outage. It should be noted that a typical year, the average from 2007 to 2009, and the year of the lock outage, 2010 to 2011, includes data beginning in August and ending in July. It is obvious that truck and rail transported the majority of the major commodities during the lock outage. From August 2010 to July 2011, truck ton-miles increased by 323 percent and rail ton-miles increased by 75.8 percent (Table 4.8). Barge transportation is the only mode that decreased in tonnage shipped. Without river access during the winter months, waterborne ton-miles decreased 13.9 percent from August 2010 to July 2011 (Table 4.8).

Table 4.8 Ton-Miles by Mode for 9 Major Commodities during a Typical Year and the Lock Outage Year			
Mode	**Ton-Miles (Typical Year)**	**Ton-Miles (Lock Outage Year)**	**Percent Change in Ton-Miles**
Truck	84,267,314	356,595,549	323.17%
Rail	739,353,067	1,299,781,719	75.80%
Barge	2,921,989,904	2,514,950,687	-13.93%
Total	**3,745,610,285**	**4,171,327,955**	**11.37%**

Source: Industry and shipping interviews, Washington State University

To calculate energy consumed for each mode and overall during the year of the lock outage, ton-miles must be multiplied by the energy intensity factors which are expressed in Btu's per ton-mile. The total amount of energy consumed and energy per ton, measured in Btu's for both a typical year and from August 2010 to July 2011, is described in the table below. Because the Btu measurement is based on ton-miles, it is logical that changes in Btu's consumed would be proportionate to changes in ton-miles. Since rail ton-miles increased by 75.8 percent during the year of the extended lock outage, Btu's consumed during this time period also increased by 75.8 percent (Table 4.9). Truck used 323 percent more energy and barge, without river access during the winter of 2010-2011, consumed 13.9 percent less energy. The net effect was a 10.1 percent increase in energy consumed during the year of the lock outage (Table 4.9). Although total energy consumed during the year of the lock outage increased, energy consumed per ton decreased by 4.8 percent from August 2010 to July 2011 (Table 4.9). Calculating energy per ton allows the author to erase the influence of the large 2010-2011 export year and focus on the actual energy consumed per ton of commodities. Energy per ton used by truck increased 266 percent and by 52 percent for rail. Barge energy consumption per ton decreased 25.6 percent during the year of the lock outage.

Table 4.9 Btu's Consumed for 9 Major Commodities during a Typical Year and the Lock Outage Year							
Mode	**Btu per Ton-Mile**	**Btu's Consumed (Typical Year)**	**Btu's Consumed (Lock Outage Year)**	**Change in Btu's**	**Btu's per Ton (Typical Year)**	**Btu's per Ton (Lock Outage**	**Change in Btu's per Ton**
Truck	552	46,515,557,320	196,840,743,081	323.17%	3,176	11,623	265.96%
Rail	305	225,502,685,519	396,433,424,239	75.80%	15,397	23,409	52.03%
Barge	418	1,221,391,779,927	1,051,249,387,056	-13.93%	83,396	62,074	-25.57%
Total		**1,493,410,022,766**	**1,644,523,554,377**	**10.12%**	**101,969**	**97,105**	**-4.77%**

The increase in energy consumed during the year of the lock outage can be attributed to an overall increase in tonnage shipped. However, the decrease in Btu's per ton can be attributed to heavy use of rail, which consumes less energy per ton-mile than barge and truck, and the increased use of barge prior to and after the lock outage.

4.4 Emissions Production Model

From the amount of energy consumed, the amount of emissions produced can be calculated. Approximately 140,000 Btu's are produced per one gallon of diesel fuel (Lee and Casavant, 1998). Therefore, from total Btu's consumed, gallons of fuel may be calculated. Emission factors are then expressed in pounds per 1,000 gallons of diesel fuel. As mentioned previously, there are five components of diesel engine emissions. The total amount of emissions, by component, created during a typical year and during the year of the lock outage for the transportation of major commodities is listed below.

The total change in emissions due to the loss of barge during the lock outage was an 8.8 percent increase in overall emissions from the transportation of nine major commodities (Table 4.10). Hydrocarbons, carbon monoxide, nitrous oxides and particulate matter increased by 85.2 percent, 4.6 percent, 6.9 percent and 21.8 percent, respectively. Sulfur oxides were the only emissions component to decrease and did so by 5.8 percent (Table 4.10). This is due to the fact that barge transportation produces more than twice the amount of sulfur oxides as truck and rail. Since barge was not available during the lock outage, sulfur oxide emissions dropped as waterborne transportation was replaced with truck and rail. Again, the general increase in emissions is a result of the increase in tonnage shipped and alternative modes used during the lock outage year in comparison to a typical year.

Table 4.10 Total Emissions from Truck, Rail and Barge for the Transportation of 9 Major Commodities during a Typical Year and the Lock Outage Year

Emissions Component	Emissions in Pounds (Typical Year)	Emissions in Pounds (Lock Outage Year)	Percent Change in Emissions
HC	271,634	503,039	85.19%
CO	599,956	627,415	4.58%
NOx	4,646,348	4,964,671	6.85%
PM	107,663	131,145	21.81%
SOx	714,131	672,842	-5.78%
Total	**6,339,732**	**6,899,114**	**8.82%**

Breaking down the total emissions into those created by each transportation mode, truck transportation of the major commodities during the year of the lock outage created an additional 323.2 percent increase in emissions (Table 4.11). The percentage increase in total emissions is the same for all five components. Rail transportation during the year of the lock outage created an increase of 75.8 percent of all emissions components (Table 4.12). The overall and component emissions increases for truck and rail are of the same percentages as the increased ton-miles produced during the year of the lock outage for both modes. Finally, during the year of the extended lock outage, barge emissions decreased overall and by component by 13.9 percent (Table 4.13). This is obvious since barge transportation was halted for almost four months for the lock outage.

Table 4.11 Total Emissions from Truck for the Transportation of 9 Major Commodities during a Typical Year and the Lock Outage Year			
Emissions Component	**Emissions in Pounds (Typical Year)**	**Emissions in Pounds (Lock Outage Year)**	**Percent Change in Emissions**
HC	70,438	298,073	323.17%
CO	7,642	32,338	323.17%
NOx	30,900	130,758	323.17%
PM	4,984	21,090	323.17%
SOx	1,827	7,733	323.17%
Total	**115,791**	**489,993**	**323.17%**

Table 4.12 Total Emissions from Rail for the Transportation of 9 Major Commodities during a Typical Year and the Lock Outage Year			
Emissions Component	**Emissions in Pounds (Typical Year)**	**Emissions in Pounds (Lock Outage Year)**	**Percent Change in Emissions**
HC	35,436	62,297	75.80%
CO	95,033	167,068	75.80%
NOx	959,997	1,687,674	75.80%
PM	24,161	42,475	75.80%
SOx	57,986	101,940	75.80%
Total	**1,172,614**	**2,061,454**	**75.80%**

Table 4.13 Total Emissions from Barge for the Transportation of 9 Major Commodities during a Typical Year and the Lock Outage Year			
Emissions Component	**Emissions in Pounds (Typical Year)**	**Emissions in Pounds (Lock Outage Year)**	**Percent Change in Emissions**
HC	165,760	142,670	-13.93%
CO	497,281	428,009	-13.93%
NOx	3,655,451	3,146,239	-13.93%
PM	78,518	67,580	-13.93%
SOx	654,317	563,169	-13.93%
Total	**5,051,327**	**4,347,667**	**-13.93%**

4.5 Conclusions for Energy Consumed and Emissions Produced Due to the Lock Outage

Total energy consumed by truck and rail transportation increased and barge energy consumed decreased with the lack of river access during the lock outage. The overall result in energy intensity during the year of the lock outage was an increase of 10 percent more Btu's being consumed. This increase in energy use is logical as more tonnage was shipped from August 2010 to July 2011 than during a typical year and truck was mostly used to replace barge during the lock outage, which is more energy intense. However, energy consumed per ton decreased 4.8 percent due to the heavy use of rail, which is more energy efficient than barge or truck, and the increased use of barge prior to and after the lock outage.

Along with energy consumption, emissions production also increased due to the lock outage. The total change in emissions due to the loss of barge during the lock outage caused a 9 percent increase in overall emissions from the transportation commodities. Percentages of hydrocarbons, carbon monoxide, nitrous oxides and particulate matter all increased; sulfur oxides were the only emissions component to decrease. Again, the general increase in emissions is a result of the increase in tonnage shipped and alternative modes used during the lock outage year in comparison to a typical year. Rail produces more emissions, including all components, when compared to barge. Truck produces more hydrocarbons and particulate matter when compared to barge. Therefore, the general increase in emissions during a transportation disruption like the extended lock outage is logical and expected.

Study Conclusions

A transportation disruption like the extended lock outage on the Columbia-Snake River has never been executed in the U.S. This study allowed the author to evaluate, in real time, the logistic, economic and environmental impact of a sustained halt in barge transportation, a key component in the Pacific Northwest multimodal transportation system. Overall, Columbia-Snake River stakeholders were well prepared and managed to navigate the disruption in transportation without incurring exorbitant costs.

Prior to the extended lock outage, major commodities in general moved in large and above average quantities on the Columbia-Snake River as shippers prepared for the extended lock outage. Those commodities moving downriver from July to December 2010 that rose above average levels for at least two months include forest products, iron ore products, wheat, vegetable products, and processed grains. Barge lines increased rates to capture additional revenue prior to the halt in business during the winter months while rail lines prepared for a possible increase in cargo loads and locomotives.

During the lock outage no movements of wheat from Idaho, eastern Washington or eastern Oregon occurred by barge. However, shippers who had to move wheat shipped it heavily by truck due to the mode's timeliness and convenience, even though the rates increased four percent. In addition, other commodity industries, such as the paper industry, used truck only to transport woodchips and lumber from the eastside of Washington and Oregon to the Portland area. However, in general, commodity shipments declined drastically during the lock outage due to the planning of shipments around the river closure.

Barge companies temporarily laid off some workers but did minimize impacts by job sharing and reduced employees hours and use of vacations. Rail lines incurred additional costs from increased railcar loads, locomotives and employee hours. Petroleum companies in the Pacific Northwest shipped more than half of their products by tanker truck during the lock outage. Following the reopening of the Columbia-Snake River, traffic returned to barge with major surges above past movement levels; this is especially true in movements downriver and of the wheat industry. Major commodities in general moved in near and above average quantities during the months of April through June 2011 in order to ship products that had been halted by extended lock outage.

During a transportation disruption, such as the extended lock outage, alternative modes are used more frequently and heavily as barge transportation is unavailable. The lock outage on the Columbia-Snake River forced commodities that would regularly travel by barge to be shifted to rail and truck. As a result, transportation costs incurred increased 37.4 percent. This dramatic increase is mostly due to the large global demand for wheat due to recent droughts in Eastern Europe. Also, truck and rail firms increased rates during the lock outage to capitalize on the lack of barge transportation.

Wheat shipment costs during the year of the lock outage were 37.4 percent more than during a typical year. Costs increased the most during the December 2010 to March 2011 time period; shipping costs increased by 67.4 percent during this time period. However, because a typical year of wheat shipments is drastically different than the year of the lock outage, cents per bushel for each year was calculated to show the actual difference in costs. During a typical year, wheat costs $0.48 per bushel to transport compared to $0.54 per bushel during the lock outage. Consequently, the cost of wheat transportation per bushel rose by six cents or only 12.7 percent during the year of the lock outage. Calculating cost per bushel allows the author to erase the influence of the large export year of 2010-2011.

In addition, energy consumed by truck and rail transportation increased and barge energy consumed decreased with the lack of river access during the lock outage. The overall result in energy intensity during the year of the lock outage was an increase of 10 percent more Btu's consumed. This increase in energy use is logical as more tonnage was shipped from August 2010 to July 2011 than during a typical year and truck was mostly used to replace barge during the lock outage, which is more energy intense. However, energy consumed per ton decreased 4.8 percent due to the heavy use of rail, which is more energy efficient than barge or truck, and the increased use of barge prior to and after the lock outage.

Along with energy consumption, emissions production also increased due to the lock outage. The total change in emissions due to the loss of barge during the lock outage caused a 9 percent increase in overall emissions from the transportation commodities. Percentages of hydrocarbons, carbon monoxide, nitrous oxides and particulate matter all increased; sulfur oxides were the only emissions component to decrease. Again, the general increase in emissions is a result of the increase in tonnage shipped and alternative modes used during the lock outage year in comparison to a typical year. Rail produces more emissions, including all components, when compared to barge. Truck produces more hydrocarbons and particulate matter when compared to barge. Therefore, the general increase in emissions during a transportation disruption like the extended lock outage is logical and expected.

The manner in which this major disruption of the river system was handled resulted in "fears not being realized." The impact was modified by the higher wheat prices in 2010 and early 2011 due to a Russian export ban on wheat, which helped generate increased shipments prior to the outage. Additionally, the communications that occurred among shippers, ports, carriers, and shipper representatives and especially the USACE resulted in as free-flowing a transportation system as was possible during this critical time.

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Appendix A: Additional Graphs and Tables

Table A.1 Annual Tonnage Shipped Downriver on the Columbia-Snake River, 1991-2010

Commodity Description	Code	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Empty Barges	1	0	0	0	0	0	0	0	0	0	0
Coal, Lignite & Coke	10	0	0	0	0	0	0	0	0	0	0
Petroleum & Petroleum Products	20	0	0	0	25	0	0	0	10,550	0	0
Crude Petroleum	21	0	1,420	0	0	0	0	0	0	0	0
Gasoline, Jet Fuel & Kerosene	22	77,994	107,805	9,865	26,056	13,679	10,673	3,370	0	9,354	8,622
Distillate, Residual & Other Fuel Oils	23	37,327	41,203	15,072	10,648	19,774	0	2,204	0	0	5,925
Petroleum Pitches, Asphalt, Naphtha & Solvents	24	1,895	0	2,400	3,348	2,150	0	0	3,200	3,600	0
Chemicals & Related Products	30	3,009	0	0	0	0	0	1,404	0	0	0
Fertilizer (Nitrogenous, Potassic, Phosphoric)	31	30,016	42,408	42,034	46,484	70,804	56,399	40,629	48,763	54,518	65,864
Organic & Inorganic Industrial Chemicals & Synthetic Materials	32	0	8,119	212	1,566	23	10,031	605	141	5,903	64
Crude Materials, Inedible, Except Fuels	40	0	0	0	0	20	0	23	101	1,362	0
Forest Products (Lumber, Logs & Woodchips)	41	1,508,795	1,324,903	1,698,042	1,489,135	1,303,790	1,025,353	1,270,470	1,134,923	1,084,040	1,022,499
Pulp, Waste Products	42	108,483	19,776	5,880	8,272	17,496	17,792	22,220	5,075	12,099	11,330
Sand, Gravel, Stone; Limestone Flux & Calcereous Stone; Phosphate Rock	43	0	16,439	5,000	208	41,556	38,253	169,169	311,250	374,044	391,050
Iron Ore; Iron Steel Waste & Scrap	44	65	0	0	0	1,729	8,690	18,850	18,938	32,910	57,149
Marine Shells (Unmanufactured)	45	0	0	0	0	0	0	0	0	0	0
Non-Ferrous Metallic Ores, Waste & Scrap	46	0	0	7,563	21	594	900	5,100	3,000	7,600	9,600
Sulfur (Liquid & Dry); Clay; Salt	47	2,600	0	5,697	2,791	2,907	716	1,135	1,156	3,346	3,131
Primary Manufactured Goods	50	9,605	828	887	0	0	21	0	0	0	300
Paper & Allied Products	51	116,090	109,752	102,345	122,716	120,214	53,992	101,619	201,426	183,326	188,205
Building Cement & Concrete; Lime; Glass	52	0	321	1,340	1,134	256	127	361	0	0	0
Primary Iron &Steel Products	53	0	0	750	0	0	1,000	0	216	2,400	0
Primary Non-Ferrous Metal Products; Fabricated Metal Products	54	12,145	32,368	30,814	37,126	33,437	44,160	34,304	36,088	42,640	46,060
Primary Wood Products; Veneer; Plywood	55	7,090	3,927	25	478	2,362	0	0	1,150	0	3,000
Food & Farm Products	60	28,042	25,804	4,903	9,848	15,974	32,172	81,013	36,031	14,308	62,555
Fresh Fish & Other Marine Products	61	5,770	10	1,285	18,623	9,763	500	32	543	1,693	2,765
Wheat	62	4,461,688	4,177,675	4,695,413	5,680,845	5,477,144	5,555,625	5,552,094	6,017,319	4,698,433	5,702,494
Corn	63	46,157	44,799	21,281	414,891	10,694	16,948	16,574	13,517	8,755	1,641
Rye, Barley, Rice, Sorghum & Oats	64	386,329	242,112	308,629	133,078	337,228	166,573	238,525	186,624	187,875	178,171
Oilseeds (Soybean, Flaxseed, & Others)	65	12,807	13,847	13,052	17,204	14,015	9,007	12,512	6,923	8,475	4,707
Vegetable Products	66	58,356	60,827	84,403	91,656	107,338	106,341	131,840	129,857	144,722	168,864
Animal Feed, Grain Mill Products, Flour & Other Processed Grains	67	65,618	110,992	108,816	109,393	93,352	101,324	74,741	110,757	174,296	209,252
Other Agricultural Products, Including Food	68	24,117	30,372	32,626	54,404	32,969	44,916	57,598	70,055	106,261	70,326
Barged Juvenile Salmonid	6,003	0	0	303	1,239	0	0	0	0	0	374
All Manufactured Equipment & Machinery	70	8,160	19,984	23,655	7,301	8,312	16,763	21,084	19,249	4,779	6,846
Waste Material (Garbage, Landfill, Sewage Sludge & Waste Water)	80	0	0	0	0	0	0	3,500	78	1,054	61
Commodity Unknown	99	8,892	9,016	10,896	13,889	11,544	6,611	5,284	2,927	12,760	250
Total		**7,021,050**	**6,444,707**	**7,233,188**	**8,302,379**	**7,749,124**	**7,324,887**	**7,866,260**	**8,369,857**	**7,180,553**	**8,221,105**

Source: U.S. Army Corps of Engineers Monthly Lock Tonnage Reports

Table A.1 Continued; Annual Tonnage Shipped Downriver on the Columbia-Snake River, 1991-2010											
Commodity Description	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Total Tons**
Empty Barges	0	0	0	0	0	0	0	0	0	0	**0**
Coal, Lignite & Coke	0	0	0	0	0	0	0	0	0	0	**0**
Petroleum & Petroleum Products	0	0	0	0	0	0	0	13,672	6,182	3,360	**31,606**
Crude Petroleum	0	0	0	0	0	0	0	0	0	0	**1,420**
Gasoline, Jet Fuel & Kerosene	3,879	6,229	4,504	6,300	3,917	0	30,741	39,470	32,621	35,822	**412,216**
Distillate, Residual & Other Fuel	0	0	3,270	0	0	0	80,103	33,337	29,831	24,521	**292,656**
Petroleum Pitches, Asphalt, Naphtha & Solvents	0	0	0	0	0	0	0	0	0	240	**16,833**
Chemicals & Related Products	3,200	0	0	0	0	0	0	0	2,450	0	**10,063**
Fertilizer (Nitrogenous, Potassic, Phosphoric)	16,983	23,810	8,525	7,933	7,400	3,047	5,416	3,123	4,088	0	**578,244**
Organic & Inorganic Industrial Chemicals & Synthetic Materials	5,172	139	266	215	65	506	8,221	16,675	23,204	4,308	**81,127**
Crude Materials, Inedible, Except Fuels	519	0	25	0	0	0	800	139	0	0	**2,989**
Forest Products (Lumber, Logs & Woodchips)	746,973	530,066	533,634	539,537	695,800	655,172	593,588	440,113	443,451	811,240	**18,407,099**
Pulp, Waste Products	9,270	6,000	15,781	1,194	6,084	3,647	0	546	102	2,700	**273,747**
Sand, Gravel, Stone; Limestone Flux & Calcereous Stone; Phosphate	916,705	984,270	745,948	649,352	882,204	791,370	785,224	1,588,162	146,211	376,607	**9,061,739**
Iron Ore; Iron Steel Waste & Scrap	43,600	48,479	63,889	47,747	54,152	61,095	67,780	71,514	74,236	113,804	**728,716**
Marine Shells (Unmanufactured)	0	77	0	0	0	0	0	0	0	0	**77**
Non-Ferrous Metallic Ores, Waste & Scrap	5,948	11,126	10,534	11,224	11,812	5,000	6,683	4,715	8,000	20,300	**125,820**
Sulfur (Liquid & Dry); Clay; Salt	4,317	3,422	1,802	1,067	3,808	2,646	3,316	2,578	49	0	**46,484**
Primary Manufactured Goods	33	58	30	187	33	78	64	0	0	0	**12,124**
Paper & Allied Products	137,152	138,624	70,318	87,197	25,920	67,448	95,283	51,457	8,034	8,787	**1,984,782**
Building Cement & Concrete; Lime; Glass	0	1,100	3,960	0	0	3,600	0	129	0	0	**12,328**
Primary Iron &Steel Products	110	2,000	28	709	3,491	0	235	0	10	300	**11,249**
Primary Non-Ferrous Metal Products; Fabricated Metal	42,692	34,425	37,788	39,326	44,690	50,574	41,830	38,123	35,489	31,383	**730,430**
Primary Wood Products; Veneer; Plywood	2,500	0	1,064	194	0	38	0	1	20	5,104	**26,874**
Food & Farm Products	87,536	50,512	70,230	60,197	15,470	22,411	7,691	21,404	41,782	20,170	**694,712**
Fresh Fish & Other Marine Products	0	0	0	30	6,945	1,515	0	0	0	0	**49,474**
Wheat	5,312,597	3,923,953	4,478,235	5,359,988	4,884,451	4,712,151	5,236,245	3,453,526	4,253,201	4,750,234	**95,755,208**
Corn	1,186	1,658	1,321	762	2,300	267	6,150	10,800	3,830	5,500	**623,531**
Rye, Barley, Rice, Sorghum & Oats	158,913	136,797	133,388	64,065	105,127	115,421	122,227	100,915	23,000	2,240	**3,325,237**
Oilseeds (Soybean, Flaxseed, & Others)	6,730	4,898	5,850	625	3,603	6,798	5,146	4,255	1,442	3,598	**155,130**
Vegetable Products	167,501	146,075	152,431	133,219	105,415	106,547	113,583	85,635	84,324	83,674	**2,213,705**
Animal Feed, Grain Mill Products, Flour & Other Processed Grains	219,845	208,315	186,379	151,856	36,158	44,822	57,490	53,655	39,149	20,667	**2,169,833**
Other Agricultural Products, Including Food	25,499	18,310	17,646	11,071	7,846	8,333	7,251	12,340	712	11,739	**635,070**
Barged Juvenile Salmonid	938	755	751	1,082	1,050	5,261	352	607	684	460	**13,761**
All Manufactured Equipment & Machinery	4,162	6,447	7,205	15,013	2,093	6,931	8,144	7,339	16,829	5,124	**213,046**
Waste Material (Garbage, Landfill, Sewage Sludge & Waste Water)	27	50	312	309	0	261	514	226	411	0	**6,803**
Commodity Unknown	1,521	1,319	954	788	223	1,400	1,412	343	1,329	800	**92,158**
Total	**7,925,508**	**6,288,914**	**6,556,068**	**7,191,187**	**6,910,057**	**6,676,339**	**7,285,489**	**6,054,799**	**5,280,671**	**6,342,682**	**138,796,291**

Source: U.S. Army Corps of Engineers Monthly Lock Tonnage Reports

Table A.2 Annual Tonnage Shipped Upriver on the Columbia-Snake River, 1991-2010											
Commodity Description	**Code**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Empty Barges	1	0	0	0	0	0	0	0	0	0	0
Coal, Lignite & Coke	10	0	0	0	0	0	0	15,270	6,900	0	0
Petroleum & Petroleum Products	20	20,841	3,734	1,785	11,451	19,872	12,562	15,314	0	16,491	1,477
Crude Petroleum	21	0	0	900	0	0	1,485	1,182	11,115	2,966	0
Gasoline, Jet Fuel & Kerosene	22	418,587	567,194	836,391	901,712	1,281,300	1,173,402	1,054,491	1,181,341	1,235,627	1,093,871
Distillate, Residual & Other Fuel Oils	23	487,745	600,244	1,285,112	655,208	676,036	710,140	870,473	820,354	849,079	837,241
Petroleum Pitches, Asphalt, Naphtha & Solvents	24	27,289	11,362	58,361	60,547	70,048	76,258	45,018	17,095	0	0
Chemicals & Related Products	30	12,550	7,377	5,450	7,200	8,500	13,700	5,950	5,150	5,900	15,186
Fertilizer (Nitrogenous, Potassic, Phosphoric)	31	279,676	132,975	218,920	388,331	238,157	72,315	113,062	56,767	38,166	64,032
Organic & Inorganic Industrial Chemicals & Synthetic Materials	32	20,982	25,375	27,530	14,751	3,500	27,500	26,650	24,650	19,500	21,470
Crude Materials, Inedible, Except Fuels	40	0	0	0	0	0	0	0	0	0	0
Forest Products (Lumber, Logs & Woodchips)	41	14,289	4,398	2,506	14,975	4,539	1,956	3,077	585	2,263	2,911
Pulp, Waste Products	42	0	260,453	28,495	34,472	45,261	43,008	47,137	8,822	3,210	0
Sand, Gravel, Stone; Limestone Flux & Calcereous Stone; Phosphate Rock	43	0	451,276	93,440	0	44	0	1,678	2,500	2,560	4,903
Iron Ore; Iron Steel Waste & Scrap	44	0	0	0	0	0	0	0	20	0	0
Marine Shells (Unmanufactured)	45	0	0	0	0	0	0	0	0	0	0
Non-Ferrous Metallic Ores, Waste & Scrap	46	0	3,266	0	1,800	0	0	0	0	0	0
Sulfur (Liquid & Dry); Clay; Salt	47	0	0	0	0	0	159	0	0	0	0
Primary Manufactured Goods	50	0	0	0	0	0	0	0	0	0	0
Paper & Allied Products	51	2,246	3,511	6,694	740	0	0	114	1,894	690	0
Building Cement & Concrete; Lime; Glass	52	0	0	2,000	0	0	84	200	0	0	0
Primary Iron &Steel Products	53	200	540	0	400	500	1,220	0	200	50	315
Primary Non-Ferrous Metal Products; Fabricated Metal Products	54	34,261	49,953	51,182	57,056	52,592	55,059	65,740	77,430	72,312	98,033
Primary Wood Products; Veneer; Plywood	55	277	0	123	0	0	0	0	0	0	1,338
Food & Farm Products	60	0	0	0	0	0	0	0	0	146	0
Fresh Fish & Other Marine Products	61	0	0	0	0	0	0	0	0	0	6
Wheat	62	3,600	0	0	6,800	3,001	25,513	1,906	6,571	19,625	13,750
Corn	63	0	0	0	0	0	2,700	0	0	0	0
Rye, Barley, Rice, Sorghum & Oats	64	0	0	0	0	0	0	0	0	3,300	0
Oilseeds (Soybean, Flaxseed, & Others)	65	0	0	0	0	0	0	0	0	0	0
Vegetable Products	66	502	0	0	52	0	938	0	0	21	0
Animal Feed, Grain Mill Products, Flour & Other Processed Grains	67	1,513	0	0	0	0	0	0	0	450	1,063
Other Agricultural Products, Including Food	68	2,824	979	0	0	70	0	0	0	606	0
Barged Juvenile Salmonid	6,003	0	0	0	0	0	0	0	0	0	0
All Manufactured Equipment & Machinery	70	12,203	30,872	27,353	14,714	26,070	22,257	33,986	15,535	13,465	18,126
Waste Material (Garbage, Landfill, Sewage Sludge & Waste Water)	80	0	0	0	0	0	7,362	149,524	184,354	205,714	236,635
Commodity Unknown	99	7,450	139,024	141,326	153,630	137,482	160,882	20,621	3,136	0	0
Total		**1,347,035**	**2,292,533**	**2,787,568**	**2,323,839**	**2,566,972**	**2,408,500**	**2,471,393**	**2,424,419**	**2,492,141**	**2,410,357**

Source: U.S. Army Corps of Engineers Monthly Lock Tonnage Reports

Table A.2 Continued; Annual Tonnage Shipped Upriver on the Columbia-Snake River, 1991-2010											
Commodity Description	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Total Tons**
Empty Barges	0	0	0	0	0	0	0	0	0	0	**0**
Coal, Lignite & Coke	0	0	0	0	0	0	0	0	0	0	**22,170**
Petroleum & Petroleum Products	0	0	0	0	0	3,587	0	3,557	3,257	0	**113,928**
Crude Petroleum	713	0	0	0	5,902	0	0	0	0	6,200	**24,263**
Gasoline, Jet Fuel & Kerosene	1,205,839	1,095,995	1,217,641	872,360	971,487	1,121,384	1,051,169	816,775	851,588	732,747	**19,348,642**
Distillate, Residual & Other Fuel	879,171	906,572	922,009	983,118	934,634	1,082,968	1,188,736	1,004,051	909,430	946,151	**17,030,832**
Petroleum Pitches, Asphalt, Naphtha & Solvents	0	0	3,157	0	0	0	0	0	0	0	**369,135**
Chemicals & Related Products	6,300	0	0	0	0	0	0	0	0	0	**93,263**
Fertilizer (Nitrogenous, Potassic, Phosphoric)	178,441	74,418	51,715	57,455	74,365	71,888	48,028	66,568	48,982	45,460	**2,299,896**
Organic & Inorganic Industrial Chemicals & Synthetic Materials	5,000	2,999	3,012	0	3,569	1,875	0	6,478	3,515	0	**238,356**
Crude Materials, Inedible, Except Fuels	1,600	0	12,000	0	1,900	0	0	0	2,000	0	**17,500**
Forest Products (Lumber, Logs & Woodchips)	618	5,858	53,862	106,675	94,569	98,193	71,960	87,292	87,170	18,354	**669,796**
Pulp, Waste Products	0	0	0	0	0	3,850	0	0	0	0	**474,708**
Sand, Gravel, Stone; Limestone Flux & Calcereous Stone; Phosphate	6,250	4,500	21,525	6,800	4,513	0	0	27,200	0	29,900	**630,189**
Iron Ore; Iron Steel Waste & Scrap	0	0	400	0	0	0	0	0	0	0	**420**
Marine Shells (Unmanufactured)	0	0	0	0	0	0	0	0	0	0	**0**
Non-Ferrous Metallic Ores, Waste & Scrap	0	0	0	0	1,000	0	0	0	0	0	**6,066**
Sulfur (Liquid & Dry); Clay; Salt	76	0	0	0	0	0	0	0	0	0	**235**
Primary Manufactured Goods	437	0	0	0	0	0	0	1,600	0	0	**2,037**
Paper & Allied Products	2,045	724	0	0	0	0	120	0	0	0	**18,778**
Building Cement & Concrete; Lime; Glass	0	0	0	0	0	0	0	50	0	0	**2,334**
Primary Iron &Steel Products	0	40	1	75	0	20	100	125	0	0	**3,786**
Primary Non-Ferrous Metal Products; Fabricated Metal	89,188	79,336	79,055	59,177	27,777	35,784	44,447	39,186	26,096	22,793	**1,102,827**
Primary Wood Products; Veneer; Plywood	0	0	0	0	0	0	0	0	0	0	**1,738**
Food & Farm Products	228	2	0	1	0	0	0	895	1,802	160	**3,234**
Fresh Fish & Other Marine Products	0	0	0	0	0	0	0	0	0	0	**6**
Wheat	6,600	3,000	0	0	9,200	0	2,957	3,400	0	14,000	**105,923**
Corn	0	0	0	0	0	0	0	0	0	0	**2,700**
Rye, Barley, Rice, Sorghum & Oats	0	3,000	0	0	0	0	0	0	0	0	**6,300**
Oilseeds (Soybean, Flaxseed, & Others)	0	0	0	0	0	0	0	0	0	0	**0**
Vegetable Products	594	0	0	0	0	0	0	0	0	0	**2,107**
Animal Feed, Grain Mill Products, Flour & Other Processed Grains	911	1,076	0	0	0	0	0	0	0	0	**5,013**
Other Agricultural Products, Including Food	500	0	0	0	0	0	0	0	0	0	**4,979**
Barged Juvenile Salmonid	4	2	0	1	0	0	0	0	0	0	**7**
All Manufactured Equipment & Machinery	20,309	22,924	12,868	12,570	7,150	5,171	11,083	8,887	3,818	29,128	**322,087**
Waste Material (Garbage, Landfill, Sewage Sludge & Waste Water)	251,789	271,518	276,810	292,036	339,698	321,204	315,107	312,427	249,374	238,062	**3,537,502**
Commodity Unknown	0	0	0	0	1,000	294	0	0	100	1,774	**766,719**
Total	**2,656,613**	**2,471,964**	**2,654,055**	**2,390,268**	**2,476,764**	**2,746,218**	**2,733,707**	**2,378,491**	**2,187,132**	**2,084,729**	**47,227,476**

Source: U.S. Army Corps of Engineers Monthly Lock Tonnage Reports

Table A.3 Monthly Tonnage Shipped Downriver on the Columbia-Snake River, July - December 2010							
Commodity	**Month**						**Total**
	Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec***	
Empty	0	0	0	0	0	0	**0**
Coal, Lignite, and Coke	0	0	0	0	0	0	**0**
Petroleum Products (General)	0	0	2,183	0	0	0	**2,183**
Crude Petroleum	0	0	0	0	0	0	**0**
Gasoline, Jet Fuel, and Kerosene	6,615	2,912	1,595	1,412	6,151	0	**18,685**
Distillate, Residual and Other Fuel Oils	0	1,423	1,432	4,411	1,636	1,657	**10,559**
Petroleum Pitches, Asphalt, and Naptha	0	0	0	0	0	0	**0**
Chemicals and Related Products (General)	0	0	0	0	0	0	**0**
Fertilizer (Nitrogenous, Potassic, Phosphoric)	0	0	0	0	0	0	**0**
Organic Industrial Chemicals	0	1,973	2,335	0	0	0	**4,308**
Crude Materials and Inedibles, Except Fuels	0	0	0	0	0	0	**0**
Forest Products (Lumber, Logs, Woodchips)	78,810	74,741	74,250	91,916	63,078	36,200	**418,995**
Pulp and Waste Products	0	0	0	0	0	0	**0**
Sand, Gravel, Stone and Crushed Rock	43,009	16,000	16,300	16,000	35,729	18,950	**145,988**
Iron Ore, Iron Steel Waste and Scrap	12,173	13,000	12,000	9,400	5,800	3,538	**55,911**
Marine Shells (Unmanufactured)	0	0	0	0	0	0	**0**
Non-Ferrous Metallic Ores	0	2,500	1,400	0	0	0	**3,900**
Sulfur (Liquid and Dry), Clay and Salt	0	0	0	0	0	0	**0**
Primary Manufactured Goods	0	0	0	0	0	0	**0**
Paper and Allied Products	1,178	336	1,486	672	701	718	**5,091**
Building Cement, Concrete, Lime and Glass	0	0	0	0	0	0	**0**
Primary Iron and Steel Products	0	0	0	0	0	0	**0**
Primary Non-Ferrous Metal Products	3,516	2,380	2,717	2,740	2,685	994	**15,032**
Primary Wood Products, Veneer and Plywood	0	0	0	0	79	0	**79**
Food and Farm Products (General)	2,623	2,440	2,453	1,484	2,541	1,800	**13,341**
Fresh Fish and Other Marine Products	0	0	0	0	0	0	**0**
Wheat	258,900	566,300	498,162	482,300	491,955	238,436	**2,536,053**
Corn	0	0	0	0	2,500	3,000	**5,500**
Rye, Barley, Rice, Sorghum and Oats	0	0	2,000	0	0	0	**2,000**
Oilseeds (Soybean, Flaxseed, and Others)	0	364	0	0	0	0	**364**
Vegetable Products	3,499	3,603	14,261	13,920	9,609	4,011	**48,903**
Animal Feed, Grain Mill Products and Flour	1,426	364	1,910	1,185	633	930	**6,448**
Other Agricultural Products, Including Food	5,161	1,266	1,410	1,484	0	0	**9,321**
Barged Fish	86	9	0	0	0	0	**95**
All Manufactured Equipment and Machinery	600	0	0	240	504	515	**1,859**
Waste Material (Garbage, Landfill, Sewage)	0	0	0	0	0	0	**0**
Commodity Unknown	0	0	0	0	0	0	**0**
Total	**417,596**	**689,611**	**635,894**	**627,164**	**623,601**	**310,749**	**3,304,615**

Source: U.S. Army Corps of Engineers Monthly Lock Tonnage Reports
* December 2010 data only includes the first nine days of the month.

Table A.4 Monthly Tonnage Shipped Upriver on the Columbia-Snake River, July - December 2010							
Commodity	**Month**						**Total**
	Jul	**Aug**	**Sep**	**Oct**	**Nov**	**Dec***	
Empty	0	0	0	0	0	0	**0**
Coal, Lignite, and Coke	0	0	0	0	0	0	**0**
Petroleum Products (General)	0	0	0	0	0	0	**0**
Crude Petroleum	0	0	0	6,200	0	0	**6,200**
Gasoline, Jet Fuel, and Kerosene	75,760	82,886	79,346	47,098	26,176	20,993	**332,259**
Distillate, Residual and Other Fuel Oils	86,920	74,371	84,963	107,639	111,805	53,599	**519,297**
Petroleum Pitches, Asphalt, and Naptha	0	0	0	0	0	0	**0**
Chemicals and Related Products (General)	0	0	0	0	0	0	**0**
Fertilizer (Nitrogenous, Potassic, Phosphoric)	5,859	3,488	3,493	3,494	3,491	0	**19,825**
Organic Industrial Chemicals	0	0	0	0	0	0	**0**
Crude Materials and Inedibles, Except Fuels	0	0	0	0	0	0	**0**
Forest Products (Lumber, Logs, Woodchips)	0	5,600	0	654	0	0	**6,254**
Pulp and Waste Products	0	0	0	0	0	0	**0**
Sand, Gravel, Stone and Crushed Rock	0	0	7,800	12,700	6,400	0	**26,900**
Iron Ore, Iron Steel Waste and Scrap	0	0	0	0	0	0	**0**
Marine Shells (Unmanufactured)	0	0	0	0	0	0	**0**
Non-Ferrous Metallic Ores	0	0	0	0	0	0	**0**
Sulfur (Liquid and Dry), Clay and Salt	0	0	0	0	0	0	**0**
Primary Manufactured Goods	0	0	0	0	0	0	**0**
Paper and Allied Products	0	0	0	0	0	0	**0**
Building Cement, Concrete, Lime and Glass	0	0	0	0	0	0	**0**
Primary Iron and Steel Products	0	0	0	0	0	0	**0**
Primary Non-Ferrous Metal Products	1,247	3,381	2,980	2,616	2,346	1,060	**13,630**
Primary Wood Products, Veneer and Plywood	0	0	0	0	0	0	**0**
Food and Farm Products (General)	0	0	0	0	0	0	**0**
Fresh Fish and Other Marine Products	0	0	0	0	0	0	**0**
Wheat	0	0	11,000	0	3,000	0	**14,000**
Corn	0	0	0	0	0	0	**0**
Rye, Barley, Rice, Sorghum and Oats	0	0	0	0	0	0	**0**
Oilseeds (Soybean, Flaxseed, and Others)	0	0	0	0	0	0	**0**
Vegetable Products	0	0	0	0	0	0	**0**
Animal Feed, Grain Mill Products and Flour	0	0	0	0	0	0	**0**
Other Agricultural Products, Including Food	0	0	0	0	0	0	**0**
Barged Fish	0	0	0	0	0	0	**0**
All Manufactured Equipment and Machinery	20	878	240	11,789	9,860	3,215	**26,002**
Waste Material (Garbage, Landfill, Sewage)	22,686	22,030	21,051	20,148	20,605	7,592	**114,112**
Commodity Unknown	0	0	0	0	0	0	**0**
Total	**192,492**	**192,634**	**210,873**	**212,338**	**183,683**	**86,459**	**1,078,479**

Source: U.S. Army Corps of Engineers Monthly Lock Tonnage Reports
* December 2010 data only includes the first nine days of the month.

Table A.5 Monthly Tonnage Shipped Downriver, December 10, 2010 - March 24, 2011					
Commodity	**Month**				**Total**
	Dec	**Jan**	**Feb**	**Mar**	
Empty	0	0	0	0	**0**
Coal, Lignite and Coke	0	0	0	0	**0**
Petroleum Products (General)	0	0	0	0	**0**
Crude Petroleum	0	0	0	0	**0**
Gasoline, Jet Fuel and Kerosene	0	0	0	0	**0**
Distillate, Residual and Other Fuel Oils	0	0	0	0	**0**
Petroleum Pitches, Asphalt and Naptha	0	0	0	0	**0**
Chemicals and Related Products (General)	0	0	0	0	**0**
Fertilizer (Nitrogenous, Potassic, Phosphoric)	0	0	0	0	**0**
Organic Industrial Chemicals	0	0	0	0	**0**
Crude Materials and Inedibles, Except Fuels	0	0	0	0	**0**
Forest Products (Lumber, Logs, Woodchips)	25,430	41,300	54,800	5,800	**127,330**
Pulp and Waste Products	0	0	0	3,500	**3,500**
Sand, Gravel, Stone and Crushed Rock	5,295	0	0	0	**5,295**
Iron Ore, Iron Steel Waste and Scrap	0	0	0	0	**0**
Marine Shells (Unmanufactured)	0	0	0	0	**0**
Non-Ferrous Metallic Ores	0	0	0	0	**0**
Sulfur (Liquid and Dry), Clay and Salt	0	0	0	0	**0**
Primary Manufactured Goods	0	0	3,000	0	**3,000**
Paper and Allied Products	32	0	0	0	**32**
Building Cement, Concrete, Lime and Glass	0	0	0	0	**0**
Primary Iron and Steel Products	0	0	0	0	**0**
Primary Non-Ferrous Metal Products	0	0	3,000	0	**3,000**
Primary Wood Products, Veneer and Plywood	0	0	0	0	**0**
Food and Farm Products (General)	0	0	0	0	**0**
Fresh Fish and Other Marine Products	0	0	0	0	**0**
Wheat	92,050	65,700	72,300	3,600	**233,650**
Corn	0	0	0	0	**0**
Rye, Barley, Rice, Sorghum and Oats	0	0	0	0	**0**
Oilseeds (Soybean, Flaxseed and Others)	0	0	0	0	**0**
Vegetable Products	0	0	0	0	**0**
Animal Feed, Grain Mill Products and Flour	596	0	0	0	**596**
Other Agricultural Products, Including Food	0	0	0	0	**0**
Barged Fish	0	0	0	0	**0**
All Manufactured Equipment and Machinery	515	130	0	0	**645**
Waste Material (Garbage, Landfill, Sewage)	0	0	0	0	**0**
Commodity Unknown	0	0	0	0	**0**
Total	**123,918**	**107,130**	**133,100**	**12,900**	**377,048**

Source: U.S. Army Corps of Engineers Monthly Lock Tonnage Reports

Table A.6 Monthly Tonnage Shipped Upriver, December 10, 2010 - March 24, 2011					
Commodity	**Month**				**Total**
	Dec	**Jan**	**Feb**	**Mar**	
Empty	0	0	0	0	**0**
Coal, Lignite and Coke	0	0	0	0	**0**
Petroleum Products (General)	0	0	0	0	**0**
Crude Petroleum	0	0	0	0	**0**
Gasoline, Jet Fuel and Kerosene	0	0	0	0	**0**
Distillate, Residual and Other Fuel Oils	0	0	0	0	**0**
Petroleum Pitches, Asphalt and Naptha	0	0	0	0	**0**
Chemicals and Related Products (General)	0	0	0	0	**0**
Fertilizer (Nitrogenous, Potassic, Phosphoric)	0	0	0	0	**0**
Organic Industrial Chemicals	0	0	0	0	**0**
Crude Materials and Inedibles, Except Fuels	0	0	0	0	**0**
Forest Products (Lumber, Logs, Woodchips)	0	135	0	0	**135**
Pulp and Waste Products	0	0	0	0	**0**
Sand, Gravel, Stone and Crushed Rock	0	0	0	0	**0**
Iron Ore, Iron Steel Waste and Scrap	0	0	0	0	**0**
Marine Shells (Unmanufactured)	0	0	0	0	**0**
Non-Ferrous Metallic Ores	0	0	0	0	**0**
Sulfur (Liquid and Dry), Clay and Salt	0	0	0	0	**0**
Primary Manufactured Goods	0	0	0	0	**0**
Paper and Allied Products	0	0	0	0	**0**
Building Cement, Concrete, Lime and Glass	0	0	0	0	**0**
Primary Iron and Steel Products	0	0	0	0	**0**
Primary Non-Ferrous Metal Products	0	0	0	0	**0**
Primary Wood Products, Veneer and Plywood	0	0	0	0	**0**
Food and Farm Products (General)	0	0	0	0	**0**
Fresh Fish and Other Marine Products	0	0	0	0	**0**
Wheat	0	0	0	0	**0**
Corn	0	0	0	0	**0**
Rye, Barley, Rice, Sorghum and Oats	0	0	0	0	**0**
Oilseeds (Soybean, Flaxseed and Others)	0	0	0	0	**0**
Vegetable Products	0	0	0	0	**0**
Animal Feed, Grain Mill Products and Flour	0	0	0	0	**0**
Other Agricultural Products, Including Food	0	0	0	0	**0**
Barged Fish	0	0	0	0	**0**
All Manufactured Equipment and Machinery	400	0	10,100	0	**10,500**
Waste Material (Garbage, Landfill, Sewage)	0	0	0	0	**0**
Commodity Unknown	0	0	0	0	**0**
Total	**400**	**135**	**10,100**	**0**	**10,635**

Source: U.S. Army Corps of Engineers Monthly Lock Tonnage Reports

Table A.7 Monthly Tonnage Shipped Downriver, April - June 2011				
Commodity	**Month**			**Total**
	April	**May**	**June**	
Empty	0	0	0	**0**
Coal, Lignite and Coke	0	0	0	**0**
Petroleum Products (General)	0	1,323	0	**1,323**
Crude Petroleum	0	0	0	**0**
Gasoline, Jet Fuel and Kerosene	1,326	10,535	0	**11,861**
Distillate, Residual and Other Fuel Oils	7,742	0	6,788	**14,530**
Petroleum Pitches, Asphalt and Naptha	0	0	0	**0**
Chemicals and Related Products (General)	2,823	0	0	**2,823**
Fertilizer (Nitrogenous, Potassic, Phosphoric)	0	0	0	**0**
Organic Industrial Chemicals	0	0	0	**0**
Crude Materials and Inedibles, Except Fuels	0	0	0	**0**
Forest Products (Lumber, Logs, Woodchips)	131,732	58,911	72,139	**262,782**
Pulp and Waste Products	96	0	0	**96**
Sand, Gravel, Stone and Crushed Rock	16,910	54,273	35,107	**106,290**
Iron Ore, Iron Steel Waste and Scrap	15,900	3,600	8,400	**27,900**
Marine Shells (Unmanufactured)	0	0	0	**0**
Non-Ferrous Metallic Ores	0	1,800	2,800	**4,600**
Sulfur (Liquid and Dry), Clay and Salt	0	0	66	**66**
Primary Manufactured Goods	0	0	0	**0**
Paper and Allied Products	1,790	2,362	2,181	**6,333**
Building Cement, Concrete, Lime and Glass	0	0	0	**0**
Primary Iron and Steel Products	0	0	0	**0**
Primary Non-Ferrous Metal Products	3,045	2,878	2,844	**8,767**
Primary Wood Products, Veneer and Plywood	128	0	0	**128**
Food and Farm Products (General)	1,350	320	1,900	**3,570**
Fresh Fish and Other Marine Products	0	0	1,010	**1,010**
Wheat	758,085	663,230	488,100	**1,909,415**
Corn	0	0	0	**0**
Rye, Barley, Rice, Sorghum and Oats	0	0	0	**0**
Oilseeds (Soybean, Flaxseed, and Others)	824	0	0	**824**
Vegetable Products	9,340	3,005	7,772	**20,117**
Animal Feed, Grain Mill Products and Flour	3,289	1,348	1,030	**5,667**
Other Agricultural Products, Including Food	68	0	0	**68**
Barged Fish	20	315	46	**381**
All Manufactured Equipment and Machinery	1,055	0	900	**1,955**
Waste Material (Garbage, Landfill, Sewage)	3,000	0	0	**3,000**
Commodity Unknown	0	0	0	**0**
Total	**958,523**	**803,900**	**631,083**	**2,393,506**

Source: U.S. Army Corps of Engineers Monthly Lock Tonnage Reports

Table A.8 Monthly Tonnage Shipped Upriver, April - June 2011				
Commodity	**Month**			**Total**
	April	**May**	**June**	
Empty	0	0	0	**0**
Coal, Lignite and Coke	0	0	0	**0**
Petroleum Products (General)	0	0	0	**0**
Crude Petroleum	0	0	0	**0**
Gasoline, Jet Fuel and Kerosene	80,045	45,759	23,921	**149,725**
Distillate, Residual and Other Fuel Oils	96,468	52,625	69,959	**219,052**
Petroleum Pitches, Asphalt and Naptha	0	0	0	**0**
Chemicals and Related Products (General)	0	0	0	**0**
Fertilizer (Nitrogenous, Potassic, Phosphoric)	25,999	3,519	9,244	**38,762**
Organic Industrial Chemicals	0	0	0	**0**
Crude Materials and Inedibles, Except Fuels	0	0	0	**0**
Forest Products (Lumber, Logs, Woodchips)	9,600	0	0	**9,600**
Pulp and Waste Products	0	0	0	**0**
Sand, Gravel, Stone and Crushed Rock	6,500	12,686	0	**19,186**
Iron Ore, Iron Steel Waste and Scrap	0	0	0	**0**
Marine Shells (Unmanufactured)	0	0	0	**0**
Non-Ferrous Metallic Ores	0	0	0	**0**
Sulfur (Liquid and Dry), Clay and Salt	0	0	0	**0**
Primary Manufactured Goods	2,015	0	0	**2,015**
Paper and Allied Products	0	0	0	**0**
Building Cement, Concrete, Lime and Glass	0	0	0	**0**
Primary Iron and Steel Products	0	0	0	**0**
Primary Non-Ferrous Metal Products	4,456	1,061	3,032	**8,549**
Primary Wood Products, Veneer and Plywood	0	0	0	**0**
Food and Farm Products (General)	0	0	0	**0**
Fresh Fish and Other Marine Products	0	0	0	**0**
Wheat	0	0	0	**0**
Corn	0	0	0	**0**
Rye, Barley, Rice, Sorghum and Oats	0	0	0	**0**
Oilseeds (Soybean, Flaxseed, and Others)	0	0	0	**0**
Vegetable Products	0	0	0	**0**
Animal Feed, Grain Mill Products and Flour	0	0	0	**0**
Other Agricultural Products, Including Food	0	0	0	**0**
Barged Fish	7	0	0	**7**
All Manufactured Equipment and Machinery	850	0	0	**850**
Waste Material (Garbage, Landfill, Sewage)	22,719	22,948	20,348	**66,015**
Commodity Unknown	0	0	0	**0**
Total	**248,659**	**138,598**	**126,504**	**513,761**

Source: U.S. Army Corps of Engineers Monthly Lock Tonnage Reports

Appendix B: Industrial, Regional, Governmental and Institutional Representatives

Below is a list of Columbia-Snake River barge transportation stakeholders, including firms, government departments and private entities, which were interviewed for this report.

ADM Milling Limited
AgVentures Northwest, LLC
Almota Elevator Company
Bernert Barge Lines, Incorporated
Blue Mountain Seed, Incorporated
BNP Lentil Company
British Petroleum
Burlington Northern Santa Fe Railway
Central Washington Grain Growers, Incorporated
Chevron Corporation
CLD Pacific Grain, LLC
Clearwater Paper
Columbia County Grain Growers
Columbia Grain International, Incorporated
Connell Grain Growers (a division of Cenex Harvest States)
Cooperative Agricultural Producers, Incorporated
Evans Grain, Feed and Seed Company
General Feed and Grain, Incorporated
Great Northwest Railroad (Watco Companies, Incorporated)
Idaho Wheat Commission
Kelley Bean Company
Lewis-Clark Terminal, Incorporated
Longview Fibre Paper and Packaging, Incorporated
Maviga N.A., Incorporated U.S.A.
Mid Columbia Producers, Incorporated
Morrow County Grain Growers, Incorporated
Northwest Grain Growers, Incorporated
Northwest Pea & Bean Company
Oregon Department of Energy
Oregon Wheat Commission
Pacific Northwest Farmers Cooperative
Pacific Northwest Waterways Association
Palouse River and Coulee City River Railroad (Watco Companies, Incorporated)
Pendleton Grain Growers
Pomeroy Grain Growers, Incorporated
Port of Lewiston

Port of Morrow County
Port of Portland
Port of Whitman County
Premier Pulses International, Incorporated
Primeland Cooperatives (a division of Cenex Harvest States)
Ririe Grain and Feed Cooperative, Incorporated
Ritzville Warehouse Company
SDS Lumber Company
Shaver Transportation Company
The McGregor Company
Tidewater Barge Lines, Incorporated
U.S. Army Corps of Engineers
U.S. Wheat Associates
U.S.A. Dry Pea and Lentil Council
Washington and Idaho Railway
Washington Grain Commission
Washington State Department of Commerce
Washington State Department of Ecology
Washington State Potato Commission
Waste Connections
Weiser Feed and Storage, Incorporated
Weyerhaeuser
Whitgro, Incorporated

Appendix C: Map of the Columbia-Snake River System