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Impact of Snake River Drawdown on Energy Consumption and Environmental Emissions from Intermodal Transportation of Grain

Impacts of a Snake River Drawdown on Energy and Emissions, Based on Regional Energy Coefficients

by

Ken Casavant

Trent Ball

Department of Agricultural Economics
Washington State University

Report prepared for:
Transportation Northwest (TransNow)
Department of Civil Engineering
129 More Hall
University of Washington, Box 352700
Seattle, WA 98195-2700

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16. ABSTRACT

The latest discussion on salmon recovery efforts in the Columbia-Snake River centers around breaching Lower Granite, Little Goose, Lower Monumental and Ice Harbor dams on the lower Snake River in eastern Washington. Snake River barge transportation is an important mode of transportation for the eastern Washington grain industry, and disruptions in barge service due to breaching are likely to have economic and environmental effects since the grain which is currently transported by barge must then rely on rail or longer hauls by truck. Losing the dams would decrease the barge transportation of wheat by nearly 40%. Several organizations in the Pacific Northwest have argued that the use of national coefficients does not accurately depict the regional energy efficiency of barges.

This study then uses regionally specific coefficients to determine the impact on energy consumption and emissions production of a drawdown of the Snake River. The coefficient results as well as the impact magnitudes are then compared to the national coefficients analysis. Regional coefficients were applied to wheat and barley movements using the same model as the Lee and Casavant study cited in this paper. The use of these preliminary regional coefficients suggests that, looking narrowly at energy and emissions environmental concerns, a drawdown of the Snake River for salmon restoration does not have a negative impact. However, this finding assumes the existing rail infrastructure can handle the increased tonnage.

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DISCLAIMER

Executive Summary

The latest discussion on salmon recovery efforts in the Columbia-Snake River centers around breaching Lower Granite, Little Goose, Lower Monumental and Ice Harbor dams on the lower Snake River in eastern Washington. If the slack water pools behind the dams are drawn down, the draft in the Snake River would be too low for barge traffic, making barge transportation unavailable on the Snake River and to the region.

Snake River barge transportation is an important mode of transportation for the eastern Washington grain industry, and disruptions in barge service due to breaching are likely to have economic and environmental effects since the grain which is currently transported by barge must then rely on rail or longer hauls by truck, both of which have different tariff rates, energy consumptions and emissions profile. A recent study, by Lee and Casavant, used national energy efficiency coefficients for both rail and barge to investigate potential environmental effects of losing the barge mode and having the rail system and trucking firms move the grains currently carried by barges.

Several organizations in the Pacific Northwest have argued that the use of national coefficients does not accurately depict the regional energy efficiency of barges. They postulate that national coefficients do not reflect the type of river system faced by Pacific Northwest barge firms nor the type of tow configuration utilized. This study, then, uses regionally specific coefficients to determine the impact on energy consumption and emissions production of a drawdown of the Snake River. The coefficient results as well as the impact magnitudes are then compared to the national coefficients analysis.

Two sources provided useful estimates of energy efficiency coefficients for the Columbia-Snake River system: barge firm self-reports (economic engineering estimates in response to a telephone survey) and modeling efforts in the Tennessee Valley Authority (TVA) and Reebie cost models.

The regional coefficients were applied to wheat and barley movements using the same model as the Lee and Casavant study, a GIS/GAMS model created by Jessup. The model analysis was run for the base case, where barge transportation was available, and then the case where barge was not available on the Snake River due to a breaching of the dams. The ton-modes by mode, for each case, were converted into energy consumption and emissions production data by the proportionate application of the energy coefficients.

It was found that estimates of modal energy consumption decrease if regional coefficients, rather than national aggregate figures are used, as was suggested by organizational spokesmen. Both rail and barge modes have significantly better energy efficiency (25% and 11%, respectively) under the estimates for the Pacific Northwest. However, the relative energy competitive position between the modes also shifts. Using current national coefficients, rail has an 11% advantage over barge; regional coefficients increase this advantage for rail over barge to 24%. It was also found that the TVA and Reebie cost models, though not used in this study, would increase the differential up to 60%.

Comparing the results of the analysis, using regional versus national coefficients, found that a Snake River drawdown would decrease energy consumption. The amount of the decrease increases from 0.61% to 2.16% (4.0 billion BTUs to 12.1 billion BTUs) when using regionally specific coefficients. Emissions production incurs a dramatic turnaround, going from an increase of 1.29% to a decrease of 2.08% (a positive 32,000 lbs to a decrease of 45,000 lbs). Thus, use of the preliminary regional coefficients suggests that, looking narrowly at energy and emissions environmental concerns, a drawdown of the Snake River for salmon restoration does not have a negative impact. However, this finding assumes the existing rail infrastructure can handle the increased tonnage.

Introduction

Salmon has been an important component of the Columbia and Snake River ecosystems since well before human activities in the region contributed to the demise of their habitat, causing several salmon species extinctions and listings as threatened or endangered. Numerous salmon recovery efforts such as fish hatcheries, habitat restoration, and transporting juvenile salmon around the dams in the Snake River have been implemented. The latest discussion of salmon recovery efforts in the Columbia-Snake River basin centers around breaching Lower Granite, Little Goose, Lower Monumental and Ice Harbor dams on the lower Snake River in eastern Washington.

A breaching would entail draining the pools behind one or more of the dams by opening the river to a free running status to help the Snake River Chinook (*Oncorhynchus tshawytscha*) and other anadromous fish by providing a more natural habitat. Proponents expect the increased water velocity produced by the breaching to decrease the mortality of traversing the dams as well as decreasing the time it takes the juvenile salmon to swim to the ocean and, thus, decreasing the risk of predation and disease associated with the slow currents in slack water pools. Specifically, the turbines will not be operating at the dams for hydro-electricity production and juvenile mortality from the dam turbines and bypass should be reduced.

When the slack water pools are drawn down as the dams are breached, the draft in the Snake River would be too low for barge traffic. This will cause barge transportation to be unavailable in the lower Snake River, which would have an impact on regional freight transportation. Historically, the ability to transport agricultural products and other freight efficiently and cost effectively has been a crucial component in the economic success of Pacific Northwest agricultural producers and other industries. In Washington, barge is potentially the most producer cost effective mode for those producers with nearby access to Snake and Columbia river ports (Jessup, et.al., 1996). Otherwise, rail is the next most cost efficient, followed by truck.

Having a complete transportation system (barge, rail, truck, air and pipeline) in Washington often means an intermodal combination of two or more modes may be the least cost method of transport over any single mode. Truck-barge combinations and truck-rail are often utilized for wheat and barley transportation. Transportation is inherently energy intensive, depending greatly on petroleum, and creating emissions that are believed to contribute to lower air quality, decreased visual aesthetics, and possibly a global greenhouse effect. Combined, freight and passenger transportation was 96.8% dependent on petroleum as its primary fuel source, with natural gas at 3% and electricity at 0.2% (Davis, 1997).

Currently in eastern Washington, wheat is transported to Portland, Oregon by rail or barge, and the majority of barley is transported by barge to Portland with a sizeable portion trucked to feedlots. Wheat is transported off farms to local elevators by trucks where elevator managers make the decision to ship the wheat to Portland via rail or via barge, in which case the wheat is trucked to a river port. Approximately 20% of eastern Washington wheat is transported by rail to Portland and the balance is shipped by barge (Newkirk, et.al.). Barley shipments bypass elevators and 38% goes from the farm to feedlots while the remainder is trucked to river ports. Less than 1% of barley is transported by rail. Snake River barge transportation is an important mode of transportation for the eastern Washington grain industry and disruptions in barge service due to breaching is likely to have economic and environmental effects since the grain which is normally transported by barge must rely on rail or longer hauls by truck, both of which have different tariff rates, energy consumptions and emissions profiles. This modal shift may be a potential conflict between salmon restoration and environmental conditions in the region.

Several studies have been done in recent years to determine the potential economic effects of breaching the four lower dams on the Snake River system. One recent study focused on the energy consumption and pollutant output changes that may arise if barges are no longer available to haul products. That study, by Lee and Casavant, 1998, used national energy efficiency coefficients for both rail and barge to investigate potential environmental effects of losing the barge mode and having the rail system and trucking firms move the grains currently hauled by barges. In the study, to be discussed later, it was found that there is an increase in energy consumption if breaching were to occur, but not at a drastic level.

Several organizations and spokesmen (Funk, Mack and Port of Portland, 1999) in the Pacific Northwest have argued that the use of national coefficients does not accurately depict the regional energy efficiency of barges. It was felt national coefficients do not reflect the type of river system that the barges in the Pacific Northwest region face nor the type of tow configuration utilized. Therefore, to use a national coefficient can feasibly misread the impact of breaching the dams. However, at the time of the Lee and Casavant study only national coefficients were available in the region.

Objectives

The overall purpose of this study was to determine the impact on energy consumption and emissions production, for transporting wheat and barley, from a drawdown of the Snake River, using regionally specific coefficients. Specific objectives were to:

1) Develop regional energy intensity and emissions production coefficients
2) Apply the regional coefficients to the model used in the Lee and Casavant study
3) Determine the impact of the drawdown on energy and emissions related to transportation
4) Evaluate the implications of using regionally specific versus national energy coefficients in analyzing impacts of drawdowns

Method of Analysis

A review of literature and survey of industry entities served to identify studies utilizing or producing energy coefficients that were specific to the Pacific Northwest. Two sources were found that could produce useful estimates of energy efficiency coefficients for the Columbia-Snake River system: barge firm self-reports (economic engineering estimates on regional movements), and modeling efforts of the Tennessee Valley Authority (TVA) model which uses the Corps of Engineers' dock to dock data for barge, and the Reebie Cost Model for rail.

Barge

Barge: Self-Reports

The first source of regional data was from a survey of all four individual barge firms that run on the Columbia-Snake River. Prior to this study the barge firms had been unwilling to release this type of information because of confidentiality and competitive concerns. Initial contact was made with the barge firms by telephone and email. In the conversations, it was mentioned that the purpose of the study was to find regional information, and a commitment was made to all parties that they would remain anonymous and their data confidential. In each case data on the tons hauled, distance traveled, and fuel consumed in the typical round trip haul was attained. The data provided by the individual barge firms was used to calculate the ton-miles/gallon, and then converted to BTUs/ton-mile. The averages for the major barge firms on the Columbia-Snake River are reported in Table 1. The barge firms had an overall average BTUs/ton-mile of 368, with a range of 347 to 407 BTUs/ton-mile.

Table 1. Self-Report Averages for all Barges on Columbia-Snake River

Barges Self-Reports	Ton-Miles/Gallon	BTUs/Ton-Mile
Average	379	368

Source: Industry survey, 2000

Barge: TVA Model Estimates

The TVA provided the second source of regional coefficients. TVA develops fuel consumption estimates for the purpose of approximating inland waterway fuel tax revenues on individual waterways. Unfortunately, the tax itself is not collected nor reported by waterway. The barge firms track their fuel purchases and pay the tax quarterly to the IRS. Without an audit of individual companies, there is no direct way to determine the taxes generated by waterway.

TVA has developed a model that uses the Corps of Engineers' Waterborne Commerce data. At its raw unpublished level, these data track individual tow movements at a dock-to-dock level. An accompanying file identifies the specific towboat. Knowing the towboat, its rated horsepower, and the distance, tonnage, and tow size moved (upriver/downriver), TVA was able to approximate fuel consumption (Greer, 2001). TVA's estimates, reported in Table 2, indicate significant decreases in energy efficiency over the four-year time period. TVA could not identify causes of these results from the model.

Table 2. Tennessee Valley Authority Energy Efficiency Coefficients

River Segment	1996 Ton-Miles/ Gallon	1997 Ton-Miles/ Gallon	1998 Ton-Miles/ Gallon	1999 Ton-Miles/ Gallon
Snake River	317	274	203	253
Columbia: Dalles to McNary	302	313	292	258
Columbia: McNary to Kennewick	229	230	229	208
Average ton-mile/gallon	283	272	241	237
BTUs/ton-mile	491	509	575	586

Source: Greer, 2000

The self-reports by the individual barge firms are certainly more energy efficient than that provided by the TVA model. In defending the findings, TVA suggested possible causes for the difference could be that the barge firms did not include dock-to-dock movement and repositioning/idling fuel consumption, or that the reports were only one-way and not round trip.

Rail

The initial objective of the study was to only acquire the regional barge efficiency for the Pacific Northwest. However, it became apparent through the discussions that regional data for the railways was also necessary in order to provide a comprehensive and directed analysis. Two methods were again used: self-reports and a Reebie model.

Rail: Self-Reports

Three railroads are prominent in the Pacific Northwest for hauling grain. Burlington Northern Santa Fe (BNSF) and Union Pacific (UP) are most dominant, with Blue Mountain Railroad acting as a gatherer/connector to the two major railways. The railways were contacted individually to determine the energy efficiency for each railroad and, again, promised confidentiality. One railroad utilized an internal model that was representative of a typical run they make in hauling grain. Energy efficiency was estimated by the major railroads from gallons consumed and freight hauled over a specific distance on a typical movement in the region. The overall BTUs per ton-mile, based on the railroads' estimates, were on average 278 for the self-reports.

Rail: Reebie Cost Model

As a check on the self-reports, model runs were done for both UP and BNSF using the Reebie Cost Model (Reebie & Associates). Each scenario was for covered hoppers (C6X) with distances ranging from 200 miles to 1200 miles. Gallons consumed over the distance, and number of cars, were also provided by the model. For the purpose of this study the runs of UP and BNSF were averaged and reported for the distance of 1200 miles, an average movement between ocean ports and either eastern Washington or the Midwest, to tidewater terminals at the ports (Table 3). BTUs per ton-mile were 234 for the model, as compared to 278 for the self-reports.

Table 3. Reebie Model Average for BNSF and UP

Type Service	Commodity	Distance (miles)	Ton-Mile/Gallon	BTUs/Ton-Mile
Unit Train	Wheat	1200	594	234

Source: Reebie & Associates, 2001

The Underlying Impact Model

Model coefficients

The coefficients utilized in the following analysis were the detailed economic-engineering self-reports from the actual barge and rail firms operating in the region. These estimates are based on specific point-to-point movements and the associated energy consumed in those movements. These coefficients are slightly less energy efficient compared to national figures and to the models developed by TVA and Reebie & Associates; thus, they can be considered to be reasonable in determining the magnitude of impacts of a Snake River dam breaching on energy consumption and emissions production.

The coefficients developed in this study were then applied to the wheat and barley movements in eastern Washington. The system of modal choice and resulting proportions of wheat and barley which are transported by truck, rail and barge used in this report are based on a Graphical Information System (GIS) database and a Generalized Algebraic Modeling System (GAMS) model created by Eric Jessup at Washington State University (Jessup, Ellis and Casavant, 1996; Jessup, 1998). The analysis utilized a Washington State Department of Transportation (WSDOT) database of eastern Washington roads with supplemental information from US Bureau of Census Topological Integrated Geographic Encoding and Referencing (TIGER) databases to construct the network of road and transportation coverage's within GIS. The GIS database contains information on the locations of Interstate, state and county roads, wheat and barley farms (referred to as townships), grain elevators with and without rail facilities, feedlots and river ports.

Using the GIS database and taking into consideration the appropriate truck, rail and barge rates and constraints, least cost wheat and barley transportation routes and modal choices were determined for various barge and no barge scenarios. Nine scenarios simulated in the GIS-GAMS model were various combinations of barge and no barge situations on the lower Snake River and associated rail and barge rate changes which may result from a loss of barge transportation. The first two used for the purpose of this study are:

- Base Case where barge transportation is available on the lower Snake River
- Case where barge is not available on the Snake River due to a breaching of the dams and rail capacity for wheat is not constrained

The base case represented current grain transportation conditions. The unconstrained rail case assumed that the historical rail grain car shortage is not a factor in modal choice for grain transportation. Rail car shortages or continued railroad abandonments, caused longer truck movements, might be expected to increase the energy and emissions impact.

The initial model's focus was on wheat and barley transportation, centered around determining per bushel costs to shippers (farmers and elevator operators) and per ton-mile (a ton of freight traveling one mile) damage costs to Interstate, state and county roads due to wheat and barley transportation under the nine different scenarios. The work in this report looks directly at the modal choice and traffic pattern shifts results from scenarios 1 and 2, and the changes in energy consumption and emissions output resulting from a loss of barge transportation on the lower Snake River. The modal share, and volumes, obtained from the model and depicted as ton-miles were then multiplied by the BTUs/ton-mile coefficients to obtain energy and emissions results.

Utilizing the amount of energy consumed, the amount of emissions produced is directly derived. Since there are approximately 140,000 BTUs per one gallon of diesel fuel, gallons of fuel from the total BTUs consumed and emission factor coefficients were then expressed in pounds per 1000 gallons of diesel fuel. The components of diesel engine emissions are broken down into the five groups: nitrous oxides (NO_x), hydrocarbons (HC), carbon monoxide (CO), particulate matter (PM) and sulfur oxides (SO_x). The total amount of emissions produced in the base case and no Snake River barge case for the transportation of wheat were then determined.

Results

Wheat

Breaching the four dams on the lower Snake River would lead to a loss of the barge mode on that section of the river, and an overall increase in the amount of truck and rail usage for freight transport. The initial Jessup model determined that breaching the dams would result in a 93.51% increase in ton-miles of additional freight transported via rail (Table 4). Truck would experience a ton-mile increase of 15.47% from the base case. Losing the dams would decrease the barge transportation of wheat by nearly 40%, since barge movements would now only be feasible on the Columbia River, near the middle of the state of Washington.

Table 4. Ton-Miles by Mode for Wheat in the Base Case and No Barge Case

Mode	Ton-Miles (Base Case)	Ton-Miles (No Barge Case)	% Change
Truck	383,528,229	442,849,331	15.47
Rail	281,904,961	545,504,291	93.51
Barge	827,443,923	503,225,117	-39.18

Source: Jessup, et.al.

Table 5 illustrates the total amount of BTUs that are consumed for the individual modes of transportation, in both the base case and the no barge case. As expected, rail and truck consumption increases by nearly 94% and 16% respectively, while barge energy consumption decreases nearly 40% from the base case. The total BTUs consumed decreases by 2.16% in the case of not having barge available for transportation on the lower Snake River, signifying that removal of barge does not increase the amount of energy that is consumed, as was suggested by industry representatives (Funk, Port of Portland), despite the increase in the need for rail transportation.

Table 5. BTU per Ton-Mile and BTUs Consumed for Wheat in the Base Case and No Snake River Barge Case (Self-Reports)

Mode	BTU/ Ton-Mile	BTUs Consumed (Base Case)	BTUs Consumed (No Barge Case)	% Change
Truck	549	210,556,992,721	243,124,282,719	15.47
Rail	278	78,369,579,055	151,650,192,898	93.51
Barge	366	302,844,475,796	184,180,392,822	-39.18
Total BTUs Consumed		591,771,047,572	578,954,868,439	-2.16

The loss of barge results in a total decrease of emissions by 2.08% from the base case (Table 6). Sulfur oxide, which is an emission factor produced largely from barges, decreases almost 23%; nitrous oxide also decreases slightly. Particulate matter, CO and HC all increase in the no barge case. However, the overall impact is a reduction in total emissions.

Table 6. Total Emissions from Truck, Rail and Barge for the Transportation of Wheat in the Base Case and the No Barge Case

Emissions Component (lbs.)	Base Case	No Snake River Barge Case	% Change
NO_x	1,540,932	1,530,319	-0.69%
HC	88,008	88,769	0.86%
CO	296,198	300,401	1.42%
PM	51,377	55,321	7.68%
SO_x	191,138	147,807	-22.67%
Total Emissions	2,167,653	2,122,618	-2.08%

Emissions attributed to truck transportation are identical to the study done by Lee and Casavant, since the truck energy consumption is assumed to be the same as the national figures (Table 7). In Tables 8 and 9 we see the effects on emission for both rail and barge transportation individually. Using rail to move additional freight tonnage, if barge is not available, increases each emission component by nearly 94%. On the other hand, barge decreases by over 39%, because of the elimination of those extended hauls to Lewiston, Idaho. Since the effect of the rail increase does not exceed the decrease in barge, the overall impact is negative.

Table 7. Emissions Attributed to Truck Transportation of Wheat in the Base Case and the No Barge Case

Emissions Component (lbs.)	Base Case	No Snake River Barge Case	% Change
NO_x	139,870	161,504	15.47
HC	318,844	368,160	15.47
CO	34,592	39,942	15.47
PM	23,512	27,233	15.83
SO_x	8,748	10,143	15.95
Total Emissions	525,566	606,982	15.49

Table 8. Emissions Attributed to Rail Transportation of Wheat in the Base Case and the No Barge Case

Emissions Component (lbs.)	Base Case	No Snake River Barge Case	% Change
NO_x	33,027	63,910	93.51
HC	315,717	610,934	93.51
CO	12,315	23,831	93.51
PM	8,397	16,248	93.51
SO_x	20,152	38,996	93.51
Total Emissions	389,608	753,918	93.51

Table 9. Emissions Attributed to Barge Transportation of Wheat in the Base Case and the No Barge Case

Emissions Component (lbs.)	Base Case	No Snake River Barge Case	% Change
NO_x	123,301	74,988	-39.18
HC	906,370	551,226	-39.18
CO	41,100	24,996	-39.18
PM	19,469	11,840	-39.18
SO_x	162,238	98,668	-39.18
Total Emissions	1,252,478	761,717	-39.18

Barley

In addition to wheat, barley is also a key product transported by rail, barge and truck in eastern Washington. Since the total amount of tons that are hauled is significantly less than wheat, the percentage effects can be expected to be more dramatic. The amount of barley transported was only 9% of that for wheat (Lee and Casavant). As seen in Table 10, both truck (107%) and rail (150%) more than double their amount of ton-miles, while barge experiences a decrease of more than 25%. Energy consumption also increased for truck and rail, but decreased for barge. The overall effect on energy consumption across all modes was an increase of 41.13% (Table 11).

Table 10. Ton-Miles by Mode for Barley in the Base Case and No Barge Case

Mode	Ton-Miles (Base Case)	Ton-Miles (No Snake River Barge Case)	% Change in Ton-Miles
Truck	52,104,728	108,102,325	107.47
Rail	37,192	93,009	150.08
Barge	76,315,265	55,825,059	-26.85

Source: Jessup, et.al.

Table 11. BTU per Ton-Mile and BTUs Consumed for Barley in the Base Case and No Barge Case (Self-Reports)

Mode	BTU/ Ton-Mile	BTUs Consumed (Base Case)	BTUs Consumed (No Barge Case)	% Change
Truck	549	28,605,495,672	59,348,176,425	107.47
Rail	278	10,339,376	25,856,502	150.08
Barge	366	27,931,386,990	20,431,971,594	-26.85
Total BTUs Consumed		56,547,222,038	79,806,004,521	41.13

Elimination of the barges on the Snake River will lead to a rise of 24.55% in total emissions output, compared to the base case (Table 12). All the emissions components will increase in the no barge case, except for sulfur oxide, which decreases by 16.65%. Looking at the individual effects of the transportation modes provides interesting results, as seen in Tables 13-15. Truck emissions consistently increase by slightly over 107% in the no barge case. For rail, the emissions double and sometimes triple when there is no barge navigation on the Snake River. As expected, the barge total emission's declines (26.85%). Overall, the effect on barley transportation with the elimination or barge on the lower Snake River is an increase in the amount of energy consumed as well as an increase in the emissions.

Table 12. Total Emissions from Truck, Rail and Barge for the Transportation of Barley in the Base Case and the No Snake River Barge Case

Emissions Component (lbs.)	Base Case	No Snake River Barge Case	% Change
NO_x	30,378	47,754	57.20
HC	126,953	151,124	19.04
CO	8,491	12,527	47.53
PM	5,065	8,098	59.90
SO_x	16,192	13,495	-16.65
Total Emissions	187,080	232,998	24.55

Table 13. Emissions Attributed to Truck Transportation of Barley in the Base Case and the No Snake River Barge Case

Emissions Component (lbs.)	Base Case	No Snake River Barge Case	% Change
NO_x	19,002	39,424	107.47
HC	43,317	89,870	107.47
CO	4,699	9,750	107.49
PM	3,268	6,782	107.53
SO_x	1,226	2,543	107.42
Total Emissions	71,512	148,369	107.47

Table 14. Emissions Attributed to Rail Transportation of Barley in the Base Case and the No Snake River Barge Case

Emissions Component (lbs.)	Base Case	No Snake River Barge Case	% Change
NO_x	4	11	175.00
HC	42	104	147.62
CO	2	4	100.00
PM	1	3	200.00
SO_x	3	7	133.33
Total Emissions	51	129	152.94

Table 15. Emissions Attributed to Barge Transportation of Barley in the Base Case and the No Snake River Barge Case

Emissions Component (lbs.)	Base Case	No Snake River Barge Case	% Change
NO_x	83,595	61,150	-26.85
HC	3,791	2,773	-26.85
CO	11,372	8,319	-26.85
PM	1,796	1,313	-26.85
SO_x	14,963	10,946	-26.85
Total Emissions	115,516	84,501	-26.85

Summary

This study was designed to determine the regionally specific impacts on energy consumption and emissions releases caused by a drawdown. An underlying objective was to determine the impact of using regional versus national coefficients in the energy and emissions analysis. The coefficients developed in this study and the national coefficients from the earlier Lee and Casavant work are collected in Table 16.

Table 16. Modal BTUs/Ton-Mile, alternative sources

Mode	Models	National	Regional
Barge	586	412	368
Rail	232	368	278
Percent Difference	60	11	24

It is first evident that estimates of modal energy consumption decrease if regional coefficients, rather than national, aggregate figures are used. Both rail and barge modes have significantly (25% and 11%, respectively) better energy efficiency under these estimates for the Pacific Northwest. Secondly, the relative energy competitive position between the two modes also shifts; using national estimates an 11% advantage for rail over barge exists as contrasted to a 24% advantage in regional coefficients. Thirdly, model estimates, not used in this study because of the successful self-report interviews, would greatly exacerbate the energy competitive difference, up to a 60% differential.

The impact on energy and emissions in wheat transportation from a drawdown is summarized in Tables 17 and 18, from regional and national coefficient perspectives.

Table 17. Wheat Transportation and Energy Consumed, millions

Coefficients	BTUs Consumed (Base Case)	BTUs Consumed (No Barge Case)	% Change
National	655,205	651,199	-0.61
Regional	591,000	578,955	-2.16

Table 18. Wheat Transportation and Emissions Produced, 000 lbs

Coefficients	Base	No Barge	% Change
National	2,473	2,505	1.29
Regional	2,168	2,123	-2.08

In both instances, a Snake River drawdown would decrease energy consumption. The amount of the decrease increases from 0.61 to 2.16%, a percentage change of over 300% (4.0 billion BTUs to 12.1 billion BTUs) when using regionally specific coefficients. Emissions production incurs a dramatic turnaround, going from an increase of 1.29% to a decrease of 2.08% (a positive 32,000 lbs to a negative 45,000 lbs). Thus, use of these preliminary regional coefficients suggests that, looking narrowly at environmental concerns, a drawdown of the Snake River for salmon restoration does not have a negative impact.

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