Centre of Excellence
Sustainability, Infrastructure & Transportation Economics

The Fraser River As A Commercial Highway

Issues, Implications and Opportunities

An examination of some of the key issues, implications and opportunities associated with utilizing the Fraser River as a Short Sea Shipping (SSS) corridor, employing river vessels to carry containers upriver from deep-sea terminals to smaller upstream node ports for dispatch to their end user destinations.

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Terminology Used In This Report

Berth	A ship's allotted place at a wharf, dock or quay, where loading/unloading activity takes place.
Deep Sea Port	Ports which can accommodate Panamax and post-Panamax size container ships.
Intermodal	Two or more different modes of transportation involved in the movement of goods to and from their destination. These modes include ships, railways and trucks.
Node Ports	Smaller versions of container terminals, usually located inland along a river. Node ports receive containers from and dispatch containers to deep sea ports.
Short Sea Shipping	The movement of bulk goods and containers from main ports, such as the Port of Vancouver, North Fraser and Fraser Port, to node ports which are located upstream along the Fraser River. Potential SSS routes would span up to 130 kilometers inland from tidewater.
TEU	Twenty-foot equivalent unit container which has the following dimensions: 20 feet long; eight feet wide, 8.5 feet high. Most containers used for transporting goods are 40 feet long (two TEUs). mTEU is one million TEUs.

Abbreviations Used in This Report

AQMP	Air Quality Management Plan	**GVGC**	Greater Vancouver Gateway Council
BC	British Columbia	**GVRD**	Greater Vancouver Regional District
BNSF	Burlington Northern Santa Fe Railway	**LFV**	Lower Fraser Valley
CAC	Common air contaminants	**IWT**	Inland Water Transport
CMA	Canada Marine Act	**NFPA**	North Fraser River Port Authority
CNR	Canadian National Railway	**NPV**	Net Present Value
CPR	Canadian Pacific Railway	**RFID**	Radio frequency identification
FRPA	Fraser River Port Authority	**SSS**	Short Sea Shipping
GDP	Gross Domestic Product	**TEU**	Twenty-foot equivalent units
GHG	Greenhouse Gas	**VPA**	Vancouver Port Authority

Contents

1.0 INTRODUCTION

Background

The container shipping industry is undergoing enormous change. Doubling and tripling of container ship size within the next ten years represents a significant challenge to port authorities around the world.

Wide-spread adoption of "just-in-time" logistics systems and increased global economic activity are resulting in demands being placed on freight transporters to provide ever faster, more efficient delivery to market.

A number of regional issues dominate the Lower Mainland port expansion agenda: congestion of major transportation routes; deteriorating air quality; and rising costs, both direct and indirect, incurred by residents, firms, and customers within the region.

The changing face of the industry, regional transportation issues, and the push for more efficient operations have prompted policymakers and industry participants to take greater notice of goods movement in the region.

While recognizing the need to remain competitive, port authorities appreciate that port expansion requires a multi-faceted infrastructure and stakeholder approach in order to be successful. A case in point is the Ministry of Transportation's Gateway Project, which endeavours to address some of the regional transportation challenges associated with expansion of port operations.

Purpose

The purpose of this study is to examine some of the key issues, implications and opportunities associated with using the Fraser River as a Short Sea Shipping (SSS) corridor, whereby inland "node" ports are connected to the tidewater deep sea port(s) via a river barge service.

Authorization

This study was authorized by the British Columbia Institute of Technology (BCIT) and the BCIT Centre of Excellence in Applied Research. Kevin Wainwright, BCIT and SFU instructor and the representative for the Centre of Excellence, acted as the client for the study. The project ran for twenty weeks, from January to May 2007.

The following individuals provided input into this project and provided guidance throughout:

- *Richard Miles*, Instructor, BCIT and Project Advisor
- *John Appleby*, Industry Contact (Delta Chamber of Commerce)
- *Fred Mandl*, Instructor, BCIT
- *Clint Morgan*, President, Delta Containers Inc.
- *Ed Kargl*, Vice-President, Fraser River Port Authority

Project Team

The initial research activities were carried out by Yumi Mooney, Lionel Lau, Bryonie Mahe, and William Wong, during their final semester as students enrolled in BCIT's Business Management Program. This phase of the project was completed during the period January to May 2007 under the direction of Richard Miles, BCIT faculty member.

Subsequently, during the summer of 2007, Sunnie Yang, a SFU graduate student in economics, was engaged to conduct additional research and to assist in the preparation of this document in a publishable format. This phase of the project was completed under the direction of Fred Mandl, BCIT faculty member.

Scope

The study began with research into the use of rivers around the world as "commercial highways". The Lower Mainland shipping industry was examined in terms of current and projected activity levels, and planned expansion of facilities to accommodate traffic growth.

An existing Short Sea Shipping (SSS) system was examined, and a framework for identifying the hard and soft costs associated with commercializing the Fraser River as an "SSS" corridor was developed.

Sources and Methods

In order to gain broad, first-hand exposure to the container delivery industry and the issues facing residents and businesses resulting from cargo transport through the Lower Mainland ports, meetings were held with John Appleby of the Delta Chamber of Commerce, Clint Morgan of Delta Containers, and Ed Kargl from the Fraser River Port Authority.

Initial research located a river commercialization study, written for the University of Southern California in 2006 entitled, "Potential Impact of Short Sea Shipping in the Southern California Region". This document provided insights into the issues that should be addressed in this report, and provided the project team with a "template", a copy of which may be found in Appendix A.

Following approval of a modified table of contents, research related to the key topics and report sections was undertaken. This involved internet research, review of academic and industry journals, and reports written by consultants and regulatory bodies in British Columbia. Most of the sources used for this paper are on a CD, available upon request.

Objectives

The objectives of this study are as follows:

- Research the Fraser River, several international river systems, and the local BC economy from the perspective of the freight transportation industry, using academic journals, databases, interviews, reports, and university libraries.

- Develop a framework for analyzing the direct and indirect costs and the economic impact of using the Fraser River as a commercial highway.

- Provide recommendations for the development of the concept of Short Sea Shipping on the Fraser River.

Assumptions

The following assumptions were made in this study:

- The Lower Mainland economy and population will continue to expand, placing ever-growing demands upon the available land and the existing road and rail networks.

- Trade between the Asian economies and North America will continue to expand, with West Coast Ports having to accommodate much of this traffic growth.

- Carriers will continue to acquire larger container ships, as these become available.

- Other West Coast ports will compete aggressively with Lower Mainland ports for market share.

Limitations

The focus of this research was limited to the Lower Fraser River basin, specifically the delta area from the Pacific Ocean at the river's terminus to Chilliwack/Agassiz upstream. Other Fraser River transportation corridors were not considered.

This study intends to give a broad overview of the feasibility, challenges and opportunities associated with Short Sea Shipping on the Lower Fraser River, and to provide a future starting point for more exhaustive studies on this subject.

Specific SSS initiative details, such as direct costs, funding requirements, or specific projections were beyond the scope of this project.

2.0 THE DYNAMICS OF GLOBAL FREIGHT TRANSPORT

Asia's massive container port development is pressuring Canada to respond by increasing container handling capacity. Rapid expansion of port capacities in China, Taiwan, South Korea, Hong Kong and Singapore is highlighting the inadequacy of port infrastructure on North America's west coast.

To illustrate, the Port of Shanghai is expanding to 52 berths, more than doubling its 2005 throughput. The Hong Kong Port Authority is studying the feasibility of a tenth terminal at Kwai Chung container port, and Busan Port in Korea will add 30 berths to handle up to 8m TEU by 2011.

With North American markets a final destination for many of the goods produced in South East Asia, and West Coast ports the closest offloading/transfer points for these goods, North American ports are under considerable and growing pressure to accommodate this expanding traffic volume through substantial terminal, road and rail infrastructure upgrades.

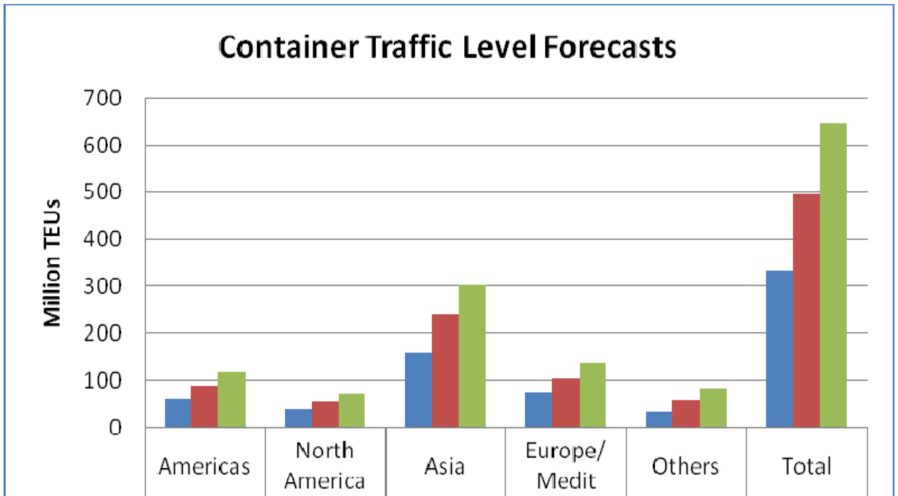
While this growth in cross-Pacific trade provides significant economic benefits to British Columbia's (and Canada's) economies, there are considerable implications for Greater Vancouver's transportation system. Most notable are traffic congestion and air pollution caused by the dramatic increase in the number of freight trucks on Lower Mainland roads.

2.1 Growth in Containerization

Growth of world freight traffic by container shipments has exceeded 10 percent annually over the past 15 years, and, according to Ocean Shipping Consultants Ltd.[1] In North America the growth rate was approximately 7 percent per year between 1990 and 2004.

[1] Michael Maloni and Eric C. Jackson, "North American Container Port Capacity: An Exploratory Analysis", Transportation Journal, Vol. 44, Issue 3, Summer 2005 p. 2

The following container traffic levels are forecast by region, to 2015:



	Americas	North America	Asia	Europe/ Medit	Others	Total
2004	62.2	41.1	159.1	74.1	36.8	332.2
2010	90.7	56.9	240.5	105.8	58.2	495.1
2015	118.8	71.6	303.4	139.5	85.6	647.3

Source: Ocean Shipping Consultants Ltd., Press Release, January 2005
Note: Reported volumes in million TEUs (A TEU, twenty-foot equivalent unit, is 20 feet long, 8 feet wide and 8 and 1/2 feet high.)

It can be seen from this forecast that North America volumes are expected to increase from 41.1 to 71.6 mTEUs by 2015, a 74.2% increase (6.7% per year).

Global volumes are forecast to rise from 332.2 to 647.3 mTEUs, a 94.9% increase (8.6% per year). Growth rates vary from port to port, depending upon their ability to accommodate increases in traffic.

2.2 Trends in Container Ship Size

Containers are stacked on deep-sea vessels, sent across the ocean, and loaded onto flat bed trucks or rail cars at the offloading terminal - various specialized handling equipment is used, as illustrated below:

Credits: Vancouver Port Authority

Container ship sizes are classified according to whether the Panama and Suez Canal are able to accommodate the vessels through their canal and lock systems.

> *Panama Canal* – The lock chambers are 305 m long and 33.5 m wide, and the maximum draught of the canal is 12.5 – 13.7 m. The length of the canal is about 86 km, and a typical passage takes eight hours. At present, the canal has two lanes. A third lane with increased lock chamber size is under consideration in order to accommodate the next generation (12,000 TEU) of vessels[2].
>
> Suez Canal – The canal is about 163 km long and 80 – 135 m wide. It has no locks. Most of the canal has a single traffic lane only, with several passing bays. It is planned to increase the depth of the canal before 2010 to handle next generation vessels.

[2] www.solentwaters.co.uk

The following table depicts the marine industry's classification of vessel sizes:

VESSEL TYPE	DIMENSIONS	CAPACITY
Small Feeder Ship breadth up to	Approx. 23.0 m	Up to 1,000 TEUs
Feeder Ship breadth	Approx. 23-30 m	1,000 – 2,5000
Panamax Ship breadth equal to Ship draught for passing canal, up to Overall ship length up to	Max: 32.2/32.3 m (106 ft) 12.0 m (39.5 ft) 294.1 m (965 ft)	2,500 – 4,500/5,000
Post-Panamax Ship breadth larger than	Max: 32.3 m	4,500/5,000 – 10,000
Suezmax Ship breadth up to Ship draught up to Draught x breadth up to Overall ship length up to	Max: 70 m 21.3 m (70 ft) Approx. 820 sq. m 500 m	10,000 – 12,000
Post-Suezmax One or more Suezmax dimensions are not met		More than 12,000

Vontainer ships can currently carry up to 9,200 TEUs, compared to the 3,400 TEU ships of the 1980's. Several countries in Asia, particularly Korea, propose to operate container ships that will carry 9,600 to 12,000 TEUs.

As of 2007, the largest container ship in the world is the Emma Maersk. This cargo ship has a stated capacity of 13,500 TEUs.[3] Presently, it carries around 11,000 TEUs. The Emma Maersk will be used to transport containers to/from China, Japan, England, Sweden, and the Netherlands.[4]

[3] Emma Maersk may be as big as a cargo ship can get
[4] ibid

Nordcapital Group and Hyundai Heavy Industries have signed contracts for the construction of eight container vessels with a capacity of 13,100 TEUs.
The ships will be delivered between April 2010 and March 2011.[5] Ships as large as 18,000 TEUs, e.g. the “Malaccamax”[6], are being planned.[7]
One limitation to ship size may ultimately be channel depths. This is the case with the Malaccamax design, where the depth of the Malacca Strait[8] may prevent this craft from operating through these waters. Similarly, these large ships are not able to transit the Panama Canal, and many East Coast and European ports lack the required water depth and turning space.[9]

This evolution of ship size is primarily driven by the economies of scale associated with the operation of such large vessels. For example, the per TEU cost on the 18,000 TEU Malaccamax is 30% less than that of a 4,800 TEU Panamax vessel. This works out to approximately US$ 40 per container.[10]

2.3 Impact on Ports

Continuing growth in containerization and the deployment of ever-larger ships will place considerable stress on port facilities during peak periods. It is estimated that more than 40% of major North American container ports already experience congestion during peak periods of the year.[11]

To maximize container-handling capacity, marine terminals need: deep channels to accommodate larger ships; efficient and sufficient equipment (e.g., gantry cranes and forklifts) to load and unload them rapidly; and enough space to store the containers. Port managers also need to have the flexibility to adopt efficiency-enhancing processes.

[5] MarineLink.com July 30, 2007
[6] Structural design of a sandwich wall as the quay wall for the future- pg. 40
[7] http://www.americanshipper.com/paid/MAY01/how_much_bigger.asp
[8] Malacca Strait – a narrow 805 km stretch of water between Peninsular Malaysia and the Indonesian Island of Sumatra
[9] ibid
[10] Dynamar Consultancy, Rotterdam
[11] Michael Maloni and Eric C. Jackson, “North American Container Port Capacity: An Exploratory Analysis”, Transportation Journal, Vol. 44, Issue 3, Summer 2005

The reality is, however, that: channel deepening is an expensive proposition; ports have limited dockside space to expand; labour unions typically oppose changes that increase efficiency and threaten jobs; port community stakeholders may present additional obstacles (e.g. security and environmental regulations).

Port capacity is affected not only by ports' on-site facilities but also by the inland transportation capacity. A recent survey of the largest North American ports identified port managers' concerns to be capacity constraints imposed by local roads, rail and truck services. None of these areas are under the jurisdiction of port authorities and operators.[12]

West Coast Port Limitations

The geography of the West Coast discourages the development of deep-sea ports. This lack of deep-sea ports causes many shipping activities to be shifted to where the most vessel-accessible, "modernized" ports are located and leads to a loss of revenue for a number of West Coast cities.

As the table below shows, the West Coast ports generally are able to handle Post-Panamax container ship sizes of approximately 4,000 to 5,000 TEUs in carrying capacity. Terminal upgrades at the various ports will make it possible to accommodate ever larger container ships

Terminal Container Ship Size Capacity[13]

	Ship Size (Panamax Class)	New Additions
Lower Mainland Ports		
Vanterm	Post and Super-Post	2 new Super Post-Panamax cranes to make it a total of 3[14]
Centerm	Post and Super-Post	2 Post-Panamax gantry cranes[15]

[12] Allison Padova, "Trends in Containerization and Capacity at Canadian Ports", Library of Parliament, 30 January 2006
[13] In 2007
[14] http://www.portvancouver.com/the_port/burrard.html
[15] http://www.portvancouver.com/trade_shipping/terminals/container/centerm.html

Deltaport	Super Post-Panamax	1 Super Post-Panamax crane to make it a total of 7[16]
Fraser River Port	Panamax	2 ship gantry cranes[17]
Prince Rupert	Super Post-Panamax	3 Super Post-Panamax cranes[18]

The North Fraser Port Authority is not mentioned in the table due to the Port's principal role of managing land areas.[19]

	Ship Size (Panamax Class)	**New Additions**
US West Coast Ports		
Seattle	Panamax, Post and Super Post Panamax	New computer software system, and efficient road access[20]
Los Angeles	Post-Panamax	12 container cranes in the Yang Ming Container Terminal[21]
Long Beach	Post-Panamax	the PierPASS Off Peak truck gate program has reduced peak-hour truck traffic by nearly 35%
Tacoma	Post-Panamax	19-acre expansion of the ITS/Husky Terminal 22-acre expansion of the Hyundai Terminal

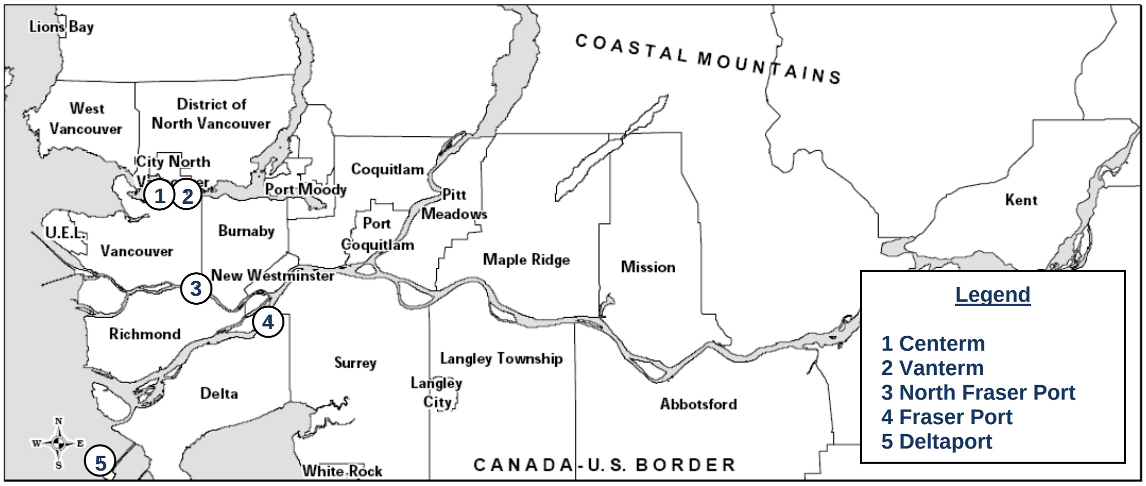
3.0 THE LOWER MAINLAND PORTS

There are three major ports with five container terminals on the west coast of Canada: Vancouver Port (Centerm, Vanterm, Deltaport), Fraser River Port and North Fraser Port.

The three lower mainland port authorities, Vancouver Port Authority, Fraser River Port Authority, and North Fraser Port Authority are federally mandated, privately owned corporations which operate under the Canada Marine Act. Currently, the three authorities are working towards amalgamating into a single entity.

Location of Existing Ports and Terminals in the Lower Mainland

16 http://www.portvancouver.com/trade_shipping/terminals/container/deltaport.html
17 http://www.fraserportauthority.com/facilities/surrey.html
18 Prince Rupert Container Terminal Development- pg. 3
19 http://www.nfpa.ca/01nfpa/index.html
20 http://www.portseattle.org/seaport/cargo/terminal5.shtml
21 http://www.portoflosangeles.org/development_Berth.htm



The three port authorities border on 16 municipalities and generate an estimated $6.3 billion in GDP.

3.1 Port of Vancouver

The Port of Vancouver, which includes the Vanterm, Centerm and Deltaport terminals, encompasses 247 km of coastline. It extends from Point Roberts at the Canada-U.S.A. border through Burrard Inlet to Port Moody and Indian Arm.

The Vancouver Port Authority (VPA) controls 6,000 hectares of water and 460 hectares of land, most of which is occupied by cargo terminals. Industry, the Province and municipalities own additional land.

The Port of Vancouver is Canada's flagship port, trading $53 billion in goods with more than 100 trading economies annually. VPA reports that port activities generate 69,200 jobs, with $4 billion in Gross Domestic Product, and $8.9 billion in annual economic output.

The Port has 25 major marine terminals: three container, seventeen bulk cargo and five break bulk. It offers three newly expanded, ISPS compliant container terminals: *Centerm* and *Vanterm* in Burrard Inlet, and *Deltaport* at Roberts Bank.

Centerm is located on the south shore of Vancouver's inner harbor, with ground transportation links to both rail and trucking. Rail service is provided by CN, CP, and BNSF. Trucks are 12 minutes from Highway 1, and less than 1 hour from the U.S. border and Interstate Highway 5. Current yard storage capacity is 12,000 TEUs, comprised of 4-high ground operation loads, 5-high ground operation empties.

Vanterm, located in Burrard Inlet, is a 76 acre, two-berth container terminal that operates five high-speed dock gantries, a modern fleet of container handling equipment and a five-track on-dock intermodal rail yard. The yard accommodates 7,000 full TEUs, stacked 3-high grounded operation loads, 5-high grounded operation empties.

Deltaport, the Port of Vancouver's largest container terminal, is located at Roberts Bank, some 40 kilometers south of Vancouver's inner harbor. The port has two berths totaling 670 meters in length and a water depth of 15.85 meters.[22]

It features six post-Panamax cranes capable of offloading 10,000 TEU vessels, and advanced computer systems.[23] The yard can accommodate 24,000 full TEUs, stacked three-high (empty containers can be stacked five-high). It is planned to increase capacity at Deltaport 850,000 to 3.2 million TEUs.[24] This will involve the establishment of a second terminal and a third berth.

As can be seen in the table below, port tonnage increased by 10.4% between 1998 and 2006. The 2006 over 2005 increase was in 2006 over 1998 was 3.8%. Container traffic increased by 162.9% and 25.0% over the corresponding periods

Port of Vancouver Traffic

	2006	2005	2002	2000	1998	2006 2005	2006 1998
Cargo '000 MT	**79,431**	76,481	62,801	76,646	71,933	3.8%	10.4%

[22] http://www.tsi.bc.ca/deltaport.htm#
[23] http://www.solentwaters.co.uk
[24] http://www.portvancouver.com/

Containers '000 TEUs	**2,208**	1,767	1,458	1,163	840	25.0%	162.9%

Port of Vancouver statistical reports 1998-2006
TEUs (twenty-foot equivalent units)

Studies predict that container traffic on the west coast of North America will triple in the next 20 years. The Port of Vancouver has the opportunity to capture 5 to 7 million TEUs by 2020. Planning is under way to increase container handling capacity at the Port of Vancouver to from 2.2 mTEUs in 2006 to 4.0 mTEUs by 2012.

Recent projects at *Vanterm* and *Centerm* increased aggregate container capacity to more than 2 mTEUs. Project highlights include:

- *Centerm* – capacity upgrade from 340,000 to almost 800,000 TEUs; conversion of existing two berths to allow acceptance of 8,000 TEU container vessels; addition of a fifth quay crane terminal, deeper berths; 8,000 feet of on-dock rail, and; 2 new Super-Post-Panamax cranes.
- *Vanterm* – capacity upgrade to 600,000 TEUs; 2 Super-Post-Panamax quay cranes.

3.2 Fraser River Port

Fraser River Port, administered by the Fraser River Port Authority (FRPA), begins at the mouth of the Fraser River, south of Vancouver B.C., and extends along the main arm of the river eastward to the Fraser Valley at Kanaka Creek, and north along the Pitt River to Pitt Lake. The jurisdiction encompasses 270 km of shoreline which borders nine Lower Mainland municipalities.

Fraser River Port, Canada's largest fresh water port and automobile port, serves thousands of small vessels annually, including some 600 cargo ships. The port generates 16,100 direct local jobs and contributes $1.3 billion to Canada's Gross Domestic Product. The FRPA handled 31.9 million tons of domestic and 4.0 million tons of international shipping in 2006. It administers several properties on Annacis Island, in Surrey, and in Richmond.

- *Annacis* is occupied by a number of privately owned trucking companies, and is home to the Port's largest specialty auto terminal. The Annacis Auto Terminal is owned by the FRPA, and handles up to 25,000 vehicles each year.

- *Surrey Properties* is owned and administered by the Fraser River Port Authority, and is mainly used as a deep-sea terminal. The predominant cargoes passing through this facility are containers, forest products, and steel.[25]

- *Richmond* is currently under development. When completed it will be used for distribution and transportation-related services. It is connected to two of the CN Rail lines.

Fraser River Port has historically specialized in handling bulk and break bulk cargoes. Among the services offered port customers is 35,850 m^2 of covered storage for weather sensitive cargo, an important consideration for buyers/sellers of raw materials and manufactured goods.

Increasingly, container shipments are handled by Fraser River Port through its Fraser Surrey Docks terminal, which can accommodate Panamax size vessels, to a maximum size of 4,500 TEUs.

The terminal can accommodate approximately 415,000 TEUs at present, with a second phase of expansion contemplating a capacity to 600,000 TEUs. Connections to all major railways British Columbia – CPR, CNR, BNSF and Southern Rail of B.C. are provided.

[25] http://www.fraserportauthority.com/pdf/Facts_04_web%20version.pdf

In 2006 the Fraser River Port handled 94,651 TEUs, a significant decrease from the 2005 volume of 372,844 TEUs. The drop is attributable to the consolidation of shipping lines in late 2005 and the subsequent reallocation of container traffic to other Pacific Northwest ports.[26]

3.3 North Fraser Port

The North Fraser Port managers 90 kilometers of shore along the north and middle arms of the Fraser River. The Port is a major link in the transportation of logs for the B.C. coastal forest industry. Port North Fraser is Canada's largest shallow draft port and handles on average 17 million tons of cargo annually.

The Port contributes over $1 billion each year in Gross Domestic Product and provides employment for approximately 8,000 persons.[27]

4.0 MOVEMENT OF GOODS AROUND THE LOWER MAINLAND

The railways are best suited to hauling large, heavy, low value loads that are not time-sensitive over distances greater than 700 km. The trucking industry specializes in moving time-sensitive goods that are usually smaller and lighter, and need to be transported less than 500 km.

Sixty five percent of containers which leave from or arrive at the Lower Mainland deep-sea terminals are transported by rail. The remaining 35% (currently 806,000 TEUs, or between 200,000 and 400,000 truck trips annually) are transported by truck.[28]

Rail

All the ports in the Lower Mainland of British Columbia are connected by rail to eastern and southern markets, as follows:

[26] Fraser River Port Facts June 2006
[27] "Global Competitor, Community Partner: An Integrated Port Entity for the Lower Mainland," Port Integration Final Report 2006
[28] Greater Vancouver Short-Sea Container Shipping Study pg. 2

PORT	RAILWAY COMPANIES
Port of Vancouver	Canadian National Canadian Pacific Burlington Northern Santa Fe
Fraser Port	Canadian National Canadian Pacific Burlington Northern Santa Fe Southern Railway of British Columbia

Ontario and Quebec (65% and 25% respectively) are the main receivers and distributors of containers to and from the West Coast of Canada. The remainder is to/from the Prairie Provinces . A significant proportion of this eastbound container traffic is destined for U.S. markets.

Truck

In 1999, 57% of The Port of Vancouver's local container business involved transport by truck. From the Centerm terminal, the primary destinations for local truck shipments were Vancouver and Richmond. These two municipalities captured 28% and 20%, respectively of heavy truck trips leaving Centerm.[29]

From Delta Port, the primary destinations for local truck freight were Richmond, Surrey, Burnaby and New Westminster. The Port of Vancouver offers access to both the Trans Canada Highway and the United States Interstate highway systems with interconnecting service over major truck routes.

Close to 40% of all trucking starting from Fraser Surrey Docks was destined for locations outside of the Lower Mainland. These were Alberta, Canada (80%) and the United States of America (20%).

[29] 1999 Lower Mainland Truck Freight Study pg. 28

Approximately 950,000 TEUs annually are transported to or from the Greater Vancouver terminals by truck. This number is almost half of the total annual container traffic in the Lower Mainland.[30]

5.0 IMPACT OF FREIGHT TRAFFIC GROWTH ON THE LOWER MAINLAND

Growth in freight traffic within the Lower Mainland is inevitable, given the area's geographic location relative to East Asian and North American markets.

So much growth has significant consequences for British Columbia's, especially the Lower Mainland's economic and social well-being. Both will be significantly affected by such factors as capacity constraints, social and environmental impacts, and public support.

5.1 Demand for Industrial Land

A study by Avison Young Real Estate in 2005 indicated that the land area used by Deltaport, Vanterm, Centerm and Fraser Surrey Docks was 438 acres. An additional 380 – 950 acres was used for port-related industrial activities, such as warehousing and distribution.[31]

The variance in the port-related acreage estimate is attributed to several factors, including variance in annual inventory turnover (the number of times each TEU moves out of the warehouse and is replaced with a new one) from company to company, the truck distribution rate (the proportion of containers transported by truck), and the warehouse utilization rate (how often the warehouse is at capacity).

Forecasted Land Requirements

[30] Container Shipping Growth and Industrial Real Estate Demand in Greater Vancouver 2005-2020 pg. 3
[31] Avison pg.5

The Avison Young report determined an additional 450 acres of land would be required for expansion of Lynnterm, Roberts Bank, Delta Port Terminal 3, and Richmond Fraser Port[32] to accommodate the traffic associated with the addition of 7-9 berths at these terminals. In addition, approximately 983 acres were forecast to be required for off-site warehousing and distribution.[33]

This requirement for an additional 1,433 acres was based on relatively conservative growth rate projections and planned expansion projects. It assumed the existing TEU/acreage relationships at ports.

If container traffic through the Lower Mainland triples[34], as predicted in some forecasts, substantial additional industrial land will be required for off-on loading, import import/export/empty container storage, freight consolidation and warehousing purposes.[35]

More infrastructure will also be required – port facilities, warehouses, railway lines and truck routes if the needs of shippers and cargo receivers are to be met.
According to the New Partners for Smart Growth Conference 2005, there are 26,000 acres of industrial land in Greater Vancouver Region, with 26% (6,800 acres) undeveloped and 80% of the undeveloped acres located south of the Fraser River.

Both the shortage of “well-located” industrial land, and the rapidly rising industrial real estate price are concerns. Increases in container traffic may lead to a higher proportion of containers being trans-loaded onto railcars for shipment to other jurisdictions (outside the Lower Mainland) with lower rent costs for warehousing.[36]

[32] ibid
[33] Assuming a 12% inventory turnover rate. The higher the turnover rate, the less space is required for the warehouse. Thus, using a 25% turnover rate would translate into the need for 657 acres of land.
[34] Avison pg.1
[35] Because Canada’s trade with China is imbalanced, with more exports going to China than imports coming in, the movement of empty containers back overseas is not as pertinent an issue for Lower Mainland ports as it is for US ports, which operate on a trade deficit.
[36] Container Shipping Growth and Industrial Real Estate Demand in Greater Vancouver 2005-2020 pg. 6

The possibility of firms leaving the Lower Mainland due to higher land costs is likely to have a negative impact on the local transportation economy. The scarcity of industrial land also puts a constraint on the expansion of the current transportation infrastructure.

5.2 Roadway Congestion

Traffic levels in the Lower Mainland are now so high that commuters and businesses are taking more notice of goods and consumer movement. Roadway congestion, partially attributable to increased heavy truck traffic, has a number of negative consequences for residents and businesses. Notable are:

- *Higher travel costs*, associated with longer commute time, longer travel distances if alternate routes are used, higher fuel consumption, and higher probability of accidents.

- *Higher labour access costs*, as individuals choose to work closer to home, relocate closer to work in a more congested and more expensive part of the region, or endeavour to pass the rising costs of travelling to work onto their employer.

- *Reduced efficiency* of transportation and transportation-dependent firms. For example, fewer deliveries of goods per hour or day, longer wait times for materials, and greater delivery times of goods to customers. Costs associated with such reduced efficiencies are ultimately passed on to the consumer, who in turn may opt to purchase goods from alternate suppliers.

Decreased efficiency of the supply chain ultimately makes Vancouver a less desirable port of call for shipping companies and overseas customers.

Several freight transportation-related developments have contributed to increasing roadway congestion in the Lower Mainland, notably:

- Growth in traffic into and out of the Lower Mainland's deep-water ports.

- Commercial expansion into eastern parts of the Lower Mainland, resulting in greater intra-regional truck traffic.

- The increased use of containers for the shipment of traditionally bulk commodities such as lumber, grain, coal (e.g. break-bulk shipping).

To illustrate the significant impact of port-related traffic on the road network, Delta Port reported 1,800 container truck and 2,100 employee service vehicle trips per day in 2003[37].

In addition to the road traffic, six trains carrying containers, each 1.8km long[38], arrived and departed from *Deltaport* each day.

With the addition of a third berth[39], traffic to/from *Deltaport* via Highway 17, Highway 99 and River Road is expected to increase to 2,400 container truck and 2,600 employee service vehicle trips per day.[40] [41] Rail traffic is expected to increase from six to nine trains both ways daily.

The B.C. Trucking Association estimates trucks are stopped or slowed in the Lower Mainland 75% of the time and truck traffic is expected to rise by 50%. On top of that, Lower Mainland's population is anticipated to grow to 3 million by 2031. The number of automobiles is increasing at a rate of 20,000 per year.
Congestion currently costs the Lower Mainland economy up to $1.5 billion a year in lost business opportunities. The cost to the trucking industry alone is estimated at $500 million, more than triple the $110 million per year just over 10 years ago.

The BC Ministry of Transportation is endeavouring to address the growing demands on the Lower Mainland's major roadway arteries with the Gateway Project, an initiative to

[37] GVGC Pre-Feasibility Study
[38] There are also CN east and westbound trains that are 3.7km in length: they are not container trains but the number of these trains is also expected to increase with the third berth expansion at Deltaport.
[39] Deltaport Third Berth Expansion Environmental Impact Analysis
[40] ibid, pg. 24
[41] ibid, pg. 48

reduce congestion along the north and south shores of the Fraser River, and the stretch of Highway 1 between Langley and Vancouver.

While moving freight traffic by rail (or river barge) is an obvious means of mitigating truck road traffic, this approach brings with it other challenges. For example the need to expand the rail network to be able to accommodate the additional freight traffic, and the effect on roadway commuters of high-frequency rail traffic through roadway crossings.

Although information on the existing railway infrastructure's capacity was not obtainable, it is realistic to assume that at some point the entire transcontinental railway infrastructure will be inadequate to meet the freight traffic demand resulting from trade with East Asia.

5.3 Air Quality Impacts

The Greater Vancouver Regional District (GVRD) air shed, situated within the Lower Fraser Valley, has mountainous terrain on three sides. While generally keeping airborne pollutants outside of the region from entering the air shed, the geography acts as a barrier to the dispersion of particulates within the region, thereby contributing to air stagnation.[42] (Refer to *Appendix H* for a description of common air contaminants, and *Appendix* I for a description of common greenhouse gases).

Exposure to solar radiation, especially during the summer months, results in ground level production of ozone (O_3). Significant amounts of rain during the winter months helps to remove airborne pollutants.[43]

As a result of the implementation of the Air Quality Management Plans (1985, 2005), levels of common air contaminants (CACs) have decreased significantly since 1988[44], however in 2004 ozone (O_3) increased beyond the target level.

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[42] Pg. 13, *South Fraser Perimeter Road Regional Air Quality Impact Assessment*
[43] ibid, pg. 13
[44] ibid, pg. 15

Studies have shown that a variety of negative consequences are associated with air pollution, notably:

- *Increased risk of respiratory and cardiovascular problems*[45], with significant cost implications for employers, and private and public sector health care plans, in terms of lost work time and benefit plan costs.

- *A lowered perception of quality of life*, for locals and tourists alike, results from the lessened visibility attributable to small particulate matter in the air shed. This could affect the Lower Mainland's ability to attract/retain skilled personnel, and to induce tourists to visit this part of the world.

Whereas air pollution emanates from many different sources, mobile emission sources – on-road vehicles, aircraft, marine vessels, trains, and non-road vehicles – are the most significant. On-road vehicle emissions contribute more than 80% of carbon monoxide and nitrogen-oxide emissions in the region.

Forecasted Air Pollution

By 2020, mobile sources are still expected to be the largest contributor of emissions in the Lower Fraser Valley.[46] The distribution of the types of vehicles contributing the most to the mobile category is expected to change however. Increases in marine activity and decreases in automobile emissions will change the profile of pollution sources.[47] Other non-road vehicles, such as lawnmowers and heavy equipment, are also expected to increase in their contribution to emissions.

Levels of smog forming pollutants[48] are expected to decline in the forecast until 2015, then increase[49] unless emission reduction policies are implemented.[50]

[45] ibid, pg. 10
[46] ibid, pg. 28
[47] ibid, pg. 28
[48] SO_x, NO_x, VOC, NH_3, $PM_{2.5}$
[49] Pg. 29, *South Fraser Perimeter Road Regional Air Quality Impact Assessment*
[50] Outside of fuel and vehicle regulations, which were included in the forecast.

6.0 LOWER MAINLAND PORT COMPETITION

6.1 Port of Prince Rupert

Located at 54° North, the Port of Prince Rupert is administered by Prince Rupert Port Authority (PRPA) and operated in partnership with Maher Terminals and Canadian National Railways.

It is a financially self-sufficient organization accountable to a Board of Directors, consisting of Port clients and appointments from three levels of government. Unlike other Port Authorities, it does not have a direct reporting relationship to the Federal Government.

Its geographic location provides the Port of Prince Rupert with a significant competitive advantage. It is North America's closest port to key Asian markets, being 436 miles/36 hours' sailing time closer to Shanghai than Vancouver, and more than 1,000 miles/68 hours closer than Los Angeles. It also has the deepest, year-round ice-free port, and thus is able to accommodate even the largest of vessels throughout the year.

A single rail line, owned/operated by Canadian National Railways, links the Port of Prince Rupert with eastern markets. Container movements by truck are via the Trans-Canada Yellowhead Highway.

Containerization of the Fairview Terminal gives the Port an annual capacity of 500,000 TEUs. The facility includes three 642 sq. meter berths with 3 Super Post-Panamax cranes, a 400 meter quay, deep enough for a 12,500 TEU vessel, and a 98% marine-to-rail intermodal infrastructure[51].

Upon completion of the first phase of expansion, the container yard will have storage space for 7,000 containers, with 3,000 spaces assigned for temporary storage. Phase II construction begins in 2007 and is expected to be completed by 2010. At that time, the Port's throughput capacity will be 2 million TEU's annually, making Prince Rupert the

[51] http://www.rupertport.com/facilities.htm

second largest handling facility on the west coast of Canada. In support of this port expansion, Canadian National Railway has committed to investing $15 million on its northern rail line to Prince Rupert in 2005.[52]

This expansion is expected to alleviate congestion at other West Coast ports to some extent.[53] Continuing Asia-North America container traffic growth, capacity limitations and customer demands for competitive services and prices relative to Prince Rupert Port will pressure Lower Mainland ports to respond with strategic initiatives. Options are: capacity expansion; price incentives; improvements in efficiency.[54]

6.2 U.S. Ports

U.S. West Coast ports represent strong competition for British Columbia. Carriers from around the world choose ports of call because of convenience, loading and unloading time, and capacity. Should a BC port become less efficient than a competitor's, the traffic could move south to an American port.

Major Ports on the U.S. West Coast[55]

[52] British Columbia Ports Strategy pg.1
[53] ibid
[54] British Columbia Ports Strategy pg. 4
[55] In 2007

	Location	Container Capacity	Other Features
Long Beach	South end of Interstate 710 (Long Beach) Freeway	6.7 million TEUs in 2005	Second busiest port in the United States; has 80 berths; East Asian trade account for >90% of shipments through the Port[56]
Los Angeles	San Pedro Bay	Eight major container terminals; 8.5 million TEUs	LA is the busiest container port in the United States.[57]
Seattle	King County in the State of Washington	2.1 million TEUs	Closest West Coast port in the United States to Asia; always expanding terminals to accommodate more container volume.[58]
Tacoma	Puget Sound in the State of Washington	Five container terminals and handled 1.47 million TEUs in 2002.[59]	>70% of the international container cargo comes from, or is going to, the central and eastern regions of North America

Their competitive advantages are:

- Well-developed infrastructure, including efficient intermodal network connections, making them better positioned to handle an increase in container shipments and ship size.
- Larger local markets.[60]
- A larger revenue base from which to fund expansion, attributable to substantially higher traffic volumes.
- Distribution centers located in or near major port terminals and large urban areas, such as is the case with the Port of Los Angeles.
- Ongoing port infrastructure projects that do not create long-term shortages of container terminal capacity.[61]

[56] http://www.polb.com/about/overview/default.asp
[57] http://www.portoflosangeles.org/
[58] http://www.portseattle.org/
[59] http://www.portoftacoma.com/home.cfm?CFID=1129621&CFTOKEN=91928364
[60] ibid pg. 10

- Advantageous financing facilities, including tax exempt municipal bonds, and direct federal investment in infrastructure and port security.

Relative to their U.S. competitors, Canadian west coast ports operate with several disadvantages which affect their ability to compete, notably:

- Physical room to expand their operations (except Prince Rupert)
- Early-stage development of distribution centers. (The Lower Mainland is slowly developing distribution centers like those in LA.[62])
- Limited federal investment in port security and river dredging
- No explicit funding for port activities under the National Marine Policy
- Different property tax regimes

BC west coast ports face challenges simply attempting to increase capacity due to lack of, or constrained, funding. Sometimes, the Port Authorities in BC need financing for land acquisitions and large-scale infrastructure that exceeds the limitations of the Canada Marine Act and the rail access under the Canada Transportation Act.[63]

The Canada Marine Act does not allow the Government of Canada to invest directly in marine infrastructure or functions including maintenance dredging.[64] The Canadian Port Authorities also have to pay the federal government for the use of real property.[65]

Port of Los Angeles

The Port complex occupies 7,500 acres of land and 69 kilometers of waterfront.[66] Containerized cargo amounts to 43.9% of the cargo that is brought into the United States by sea and moves through the Port of Los Angeles (L.A.)[67].

[61] ibid pg. 10
[62] British Columbia Ports Strategy pg. 18
[63] ibid pg. 12
[64] ibid pg. 12
[65] British Columbia Ports Strategy pg. 12
[66] http://www.portoflosangeles.org/DOC/POLA_Fact_Sheet.pdf
[67] http://www.cbp.gov/xp/cgov/newsroom/full_text_articles/tours_cbp_facilities/giant_pacific_rim.xml

The Port of Los Angeles primarily handles vessels that transport containers carrying value-added cargo[68]. On an average day, 16 ships arrive at the Port of L.A from foreign ports, bringing five million TEUs each year[69].

In the fiscal year of 2006, the value of the goods shipped by container entering and exiting the port equaled US $191 billion[70].

High traffic at the port increases air pollution in the region. Idling vessels, waiting to be loaded and unloaded, burn diesel fuel. To combat pollution, the Port of Los Angeles was the first port to convert into an "electrified port". Ships entering the port can reduce emissions by "plugging in" to the port facility for electric power.[71]

Due to the size of the market and access to resources, the Port of Los Angeles provides more services to customers than the Port of Vancouver, making it an appealing logistics hub. The Port of Vancouver, however, offers the advantage of being considerably closer to the Asian market than LA, thus providing reduced cargo transit time and associated cost savings.

7.0 THE FRASER RIVER

7.1 The Geography

From its headwaters on the Pacific slope of the continental divide within Mount Robson Provincial Park, the Fraser River flows along a 1375 kilometer course to the ocean in the southwest corner of BC. The entire basin drains 13 main watersheds - one third of the area of the province - and is home to more than 2.8 million people. It accounts for 80% of the provincial and 10% of the national gross domestic product.[72]

[68] http://www.bts.gov/publications/americas_freight_transportation_gateways/highlights_of_top_25_freight_gateways_by_shipment_value/port_of_los_angeles/
[69] http://www.cbp.gov/xp/cgov/newsroom/full_text_articles/tours_cbp_facilities/giant_pacific_rim.xml
[70] http://www.dot.gov/affairs/bts3604.htm
[71] http://www.ens-newswire.com/ens/jun2004/2004-06-21-04.asp
[72] Canadian Heritage River System

The river courses through a variety of terrain, including a broad, mountain-rimmed trench, rolling hills and the flatlands of the interior plateau, canyon lands, and a flood plain extending 130 km from Hope to Vancouver and the coast.

Melting snow is the main source of the river, resulting in peak flow rates of 12,000 m^3/sec, or higher during the freshet.[73] Water volume is lowest during the winter months, with typical volume being in the 1,000 m^3/sec range. The lower reaches of the river are subject to a 5 meter tidal range, creating salt wedges (salt water from the ocean pushing its way under the fresh water up the river) during tidal action.

The lower Fraser River is characteristically grayish brown, the result of a high silt content. It is estimated the river's annual silt load is 20 million tons of silt, clay and gravel, of which 3.5 million tons are deposited in the lower reaches of the river valley and the remainder in the Strait of Georgia. These riverine deposits necessitate periodic dredging in order to maintain marine traffic on the river's lower reaches.

The Fraser River is a globally significant ecosystem which supports a rich diversity of plants and animals. The Basin boasts one of the world's most significant salmon river systems, supporting six salmon species, including steelhead, and 65 other species of fish.

The Fraser River basin is also British Columbia's most productive waterfowl breeding area, home to hundreds of species of birds and mammals, as well as reptiles, amphibians and insects.

7.2 River Transportation: A Historical Perspective[74]

Prior to the arrival of European explorers and settlers, First Nations groups established villages along the Fraser River and used the river as a transportation and trading route. The principal mode of river transport for the Sto:lo and other Coast Salish peoples was canoes carved from cedar logs.

[73] Baird Software
[74] Miscellaneous historical sources

The arrival of Europeans in the area resulted in the establishment of a Hudson's Bay fur trading post in 1827 at Langley. Trade along the river was facilitated by bateaux river boats, which the voyageurs from Fort Langley used to transport trade goods from and furs to the Fort.

A paddle wheeler, the "Beaver", was the first steam powered vessel on the Pacific Coast of North America. It commenced operations on the lower Fraser River in 1837, connecting the various Pacific coast forts with Fort Langley.

Two gold rushes – the Fraser River gold rush near Yale, and the Barkerville gold rush in the Cariboo region of BC – brought thousands of stampeders to the area, and provided the impetus to establish a marine passenger and freight service along the lower Fraser River.

Sternwheelers, it turned out, were the perfect riverboats for the Fraser River. Their shallow hull allowed them to cross the river's ever-shifting bars. The use of lightweight planks reduced the vessels' draught making it easier to float in shallow water, and to maneuver them through the river's unpredictable shoals.

A further advantage was that sternwheelers could nose into a riverbank while keeping the paddle slowly turning in deeper water. This allowed the craft to put in practically anywhere along the river to load and unload passengers and cargo.

Following the discovery of gold near Yale, BC, in 1858, the paddle wheeler "Surprise" arrived in Hope, laden with gold seekers, their baggage and freight. By 1860, when the Fraser Canyon Gold Rush was starting to decline, more than a dozen sternwheelers were working on the Fraser River between New Westminster, Fort Hope and Port Douglas. More were arriving from American waters - or were being built locally. News of the Cariboo Gold Rush in 1862, and the subsequent construction of the Cariboo Wagon Road, rejuvenated the by then declining transportation industry.

Farm settlement followed the Gold Rush era (1858-93). The fertile soils and moderate climate in the Fraser Valley was ideal for food production. Roads were practically nonexistent and the riverboats continued to work, serving the needs of farmers and other settlers throughout the Fraser Valley. The boats were also the principal means of moving materials for the construction of the Canadian Pacific Railway through the Fraser Canyon in the early 1880's.

When the Canadian Pacific Railway (CPR) was completed along the north side of the river in 1885, it provided a more efficient means of transporting goods and people. The establishment of the BC Electric Interurban Railway in 1910, and an ever-expanding network of roads in the 1920's ultimately spelled the demise of sternwheelers on the Fraser River.

River-based transport along the lower Fraser River experienced a resurgence during World War II, as vast quantities of raw materials were required in order to support the war effort. Commercial waterborne transport, however, developed largely around the use of tugboats and barges, rather than sternwheelers.

Tugboats and barges proved to be efficient because of the shallow draught and the massive carrying capacity of a barge (one barge carries as much cargo as 65 trucks or 15 jumbo rail cars).

Barges were used to transport bulk goods, such as aggregates, wood chips and newsprint to riverside manufacturers and customers. A second, specialized use of tugboats – the towing of log booms to riverside mills – also became common.

More recently, a new transportation mode, break-bulk cargo shipping, evolved. Cargoes previously shipped in bulk are loaded into 20 or 40-foot freight containers, for subsequent transport to local or international markets. An emerging development is the transport of break-bulk loaded containers via barge to deep sea terminals for transport to overseas destinations.

Today, deep-sea, bulk and container vessels ply the Fraser River estuary to and from cargo terminals and auto terminals near New Westminster.

7.3 Challenges Facing the Fraser River Basin

At this time the Fraser River Basin faces many challenges, including urban sprawl, industrial development and environmental degradation.

- *Population* - according to the Fraser Basin Council's 2006 Sustainability Snapshot report, the Fraser Basin in 2003 was estimated to be 2.8 million people. This figure is expected to increase to 4.0 million by 2031.
- *Air pollution* - total greenhouse gas (GHG) emissions from human activity have grown by 30% since 1990, and in 2004 reached a 15-year high of 16.8 megatonnes. The transportation sector underwent a 42% increase in emissions, and accounted for 40% of total BC emissions.
- *Particulate matte*r – attributable to forestry and industrial sources, vehicle emissions, domestic burning and forest fires – has worsened in 4 of 6 communities since 2000. Ground level ozone has worsened in 6 of 8 communities.
- *Fish stocks* - salmon run size, catch and harvest rates have declined since 1990. Steelhead stocks are classified as "Extreme Conservation Concern". All four Fraser Basin sturgeon stocks were designated as "Endangered" by COSEWIC in 2003.[75]

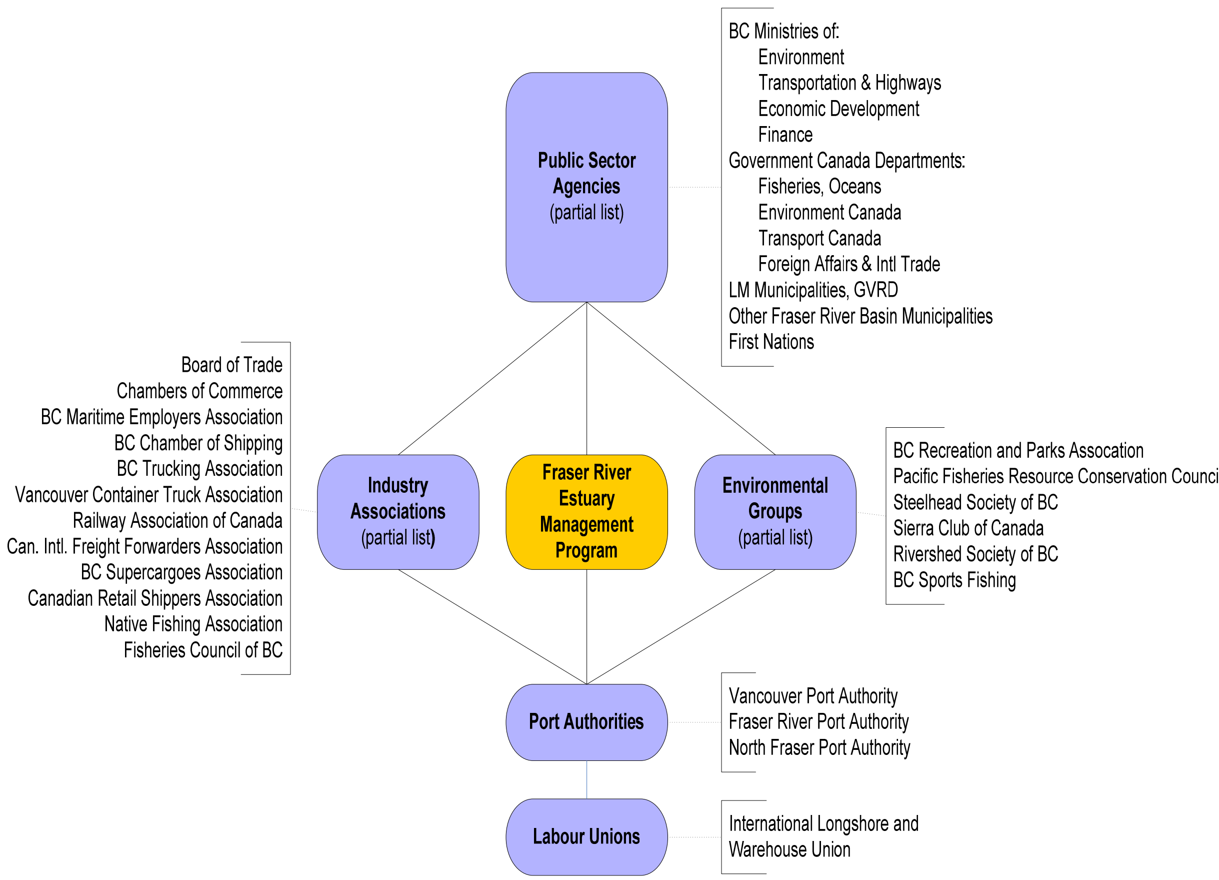
These challenges are reflected in the Fraser River Basin's complex governance system and has implications for the degree to which support can be mustered for a Fraser River based Short Sea Shipping (SSS) initiative.

7.5 Fraser River Stakeholders

[75] Committee on Status of Endangered Wildlife in Canada

In the context of this report, a stakeholder is a party which has a vested interest in seeing a project come to fruition, or to fail. The reasons for support of, or opposition to, a project, such as a Fraser River Short Sea Shipping initiative, by a stakeholder depends on that party's definition of what constitutes value, or the lack of it.

As is evident from the schematic below, many parties consider themselves to have an interest with respect to the use of the Fraser River, and a myriad of actual (or perceived) jurisdictional overlaps and boundaries exist concerning governance of this river corridor.



Fraser River Estuary Management

A complex governance system, coordinated under the Fraser River Estuary Management Program (FREMP), exists within the estuary. It is administered by six stakeholders – Environment Canada, Fisheries & Oceans Canada, the Ministry of Environment, the North Fraser River Port Authority, and the Greater Vancouver Regional District. This body is responsible for coordinating all environmental management and decision-making pertaining to the estuary.

In 1994, the FREMP partners, in consultation with a wide variety of interests, developed the Estuary Management Plan for the Fraser River ("A Living Working River"). This plan has helped manage the estuary's economic and biological productivity by integrating economic development and environmental protection.
The vision of the Estuary Management Plan is:

> *"A sustainable Fraser River estuary characterized by a healthy ecosystem, economic development opportunities, and continued quality of life in and around the estuary."*

The Program espouses the following principles for conserving and enhancing the estuary: "keep the estuary healthy; conserve, enhance and protect natural habitat; take a precautionary approach".

In applying the precautionary principle to decision-making concerning use of the Fraser River, FREMP indicates that if a proposed use might cause severe or irreversible harm to the environment – for example the loss of biodiversity attributable to the elimination of certain fish stocks - in the absence of a scientific (or other) consensus that harm would not ensue, the burden of proof falls on those who would advocate taking the action.

Among FREMP's accomplishments to date are: the creation and enhancement of habitat; recommendations aimed at improving water quality; development of a habitat inventory and classification system; the establishment of dredge management and log storage guidelines; the exploration of intermodal transportation issues; and the expansion of regional and municipal parks systems.

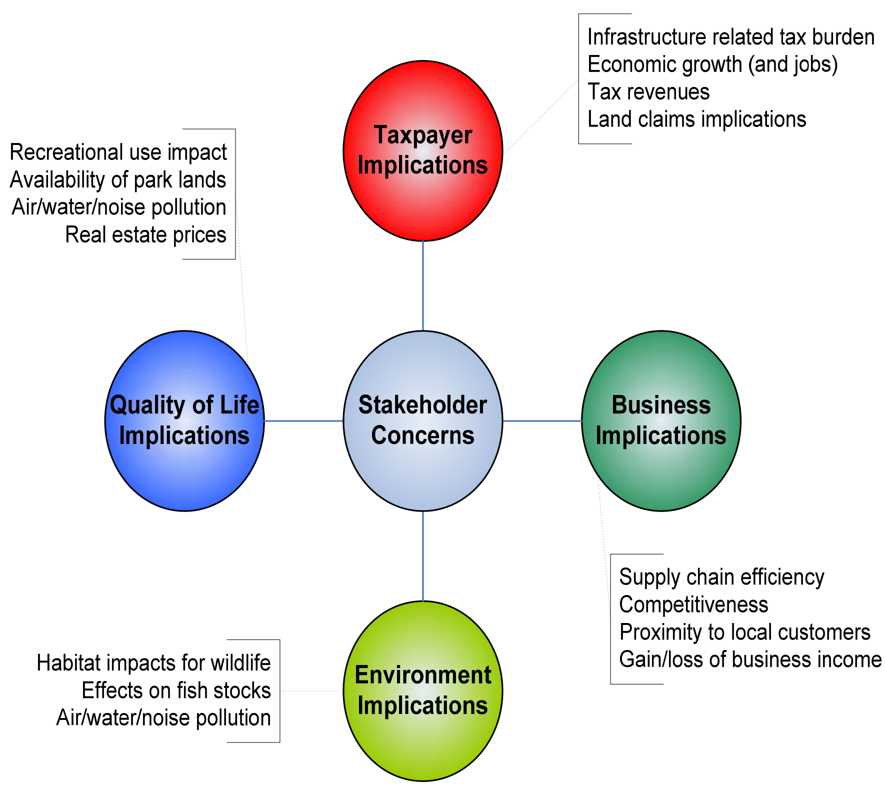
A rigorous approval process is in place for all projects which might affect the estuary.

Government, Industry & Environmental Stakeholders

Given the social, economic and environmental factors inherent in today's multi-purpose use of the Fraser River, different visions, and priorities – social, economic and environmental – are subscribed to, by a variety of interest groups.

Invariably, these stakeholder visions are incompatible (and sometimes myopic), with the distinct possibility that inflexible positions end up being adopted, and inaction being the inevitable outcome.

The schematic below identifies the four groups of broad stakeholder concerns, and provides some examples of key issues which they are likely to be focused on.



A detailed breakdown of public and private sector stakeholders and their concerns is provided in *Appendix C*.

One conclusion to be drawn from examination of these tables is that municipal/regional governments, being accountable to the Province, local businesses and individual taxpayers, are faced with the greatest number of short sea shipping related concerns.

The non-government stakeholders are, depending upon whether they are commercial entities or non-commercial special interest groups, principally focused on business or environmental/recreational outcomes.

8.0 INLAND WATERWAY TRANSPORT COMPARISONS

The purpose of this section is to broadly compare various river systems internationally in an attempt to learn more about Short Sea Shipping in practice. The Yangtze River in China, and the Rhine River in Germany are studied in this section with special focus on the commercialization of the marine waterways in the respective regions.

8.1 Yangtze River Transportation Corridor

Of the world's great rivers, none has greater potential for commercial development than the Yangtze. More than half of its 5,920 kilometers is navigable. Within its basin live at least 400 million Chinese, and its industrial base accounts for 40 percent of China's GDP. In recent years 80 percent of all commercial inland water traffic in China took place on the Yangtze.

The Chinese government has spent billions to facilitate intensified use. This has been undertaken with the recognition that the river's potential has barely been tapped (just 15% of its capacity – estimated to be the equivalent of six rail lines of similar length), and that expanding the river's capacity could be accomplished at far lower cost than similar upgrades to rail or road networks. Productive land did not need to be taken out of service, and few citizens would need to be displaced.

In recognition of these advantages, various initiatives have been undertaken, including underwater reef demolition, dredging, the installation of riverbank navigational aids, and the mandatory use of Global Positioning Systems (GPS) by all river barges.

The pressure for expanded use of the Yangtze is attributable to the massive shift of manufacturing to China's interior provinces. Significant increases in the cost of land and labour in coastal cities have encouraged businesses to move their operations inland, and this geographic shift, in turn, necessitates a corresponding restructuring of China's transportation system to remain competitive.

The need for a revitalized transportation system in China is illustrated by the following statistics:

- *Containerized Traffic Volume* - in 2005, China's coastal ports handled 75 million TEUs. The government now forecasts that these ports will handle in excess of 140 mTEUs by 2010. Twenty seven percent of the world's total containerized cargo is now handled by the country's three main ports – Hong Kong, Shanghai and Shenzen.

- *Transport by Truck* - trucking has emerged as the most viable, but expensive, way to move most goods over long distances. It accounts for 75% of the freight value moved today. Little of this traffic is containerized.

- *Transport by Rail* - the rail system is supported by 18 major intermodal rail hubs and 40 mid-size stations, strategically located at ports and inland centers. The network is intended to rationalize container traffic at the more than 600 mixed-use facilities currently being operated.

    - Freight demand has outstripped rail supply on virtually every major route
    - Only 3% of the total freight volume moved by rail is containerized
    - Local containers are considerably smaller than international standard containers, hampering intermodal freight movement.

With challenges ahead for the long-haul trucking industry and rail not ready to meet growing demand, efforts to expand container-on-barge (COB) service along the Yangtze is becoming more attractive.

Container-On-Board Transport on the Yangtze River

Whereas for centuries barges have transported bulk materials, iron ore, crude oil and coal, COB shipping on the Yangtze began in 1986.

As of 2006, approximately 35 major barge companies were providing container service to two dozen Yangtze ports, extending 2,400 km upstream from Shanghai. Of these, the top five control about 50% of capacity. Twenty international shipping companies have established close ties to the major operators, and offer a range of services complimentary to international container transport.

Among the major players involved in inland waterbased transport are China Minsheng which moves 65% of the containers to and from upstream areas around Chongqing, and state owned COSCO with a 90+ fleet serving the middle reaches of the river, particularly around Wuhan and the ports of Anhui Province. Nanjingtonghai and Jihai Shipping each claim a third of container traffic along the busy Nanjing-Shanghai section.

Waterborne traffic on the Yangtze has been catalyzed by two major developments – the construction of the Three Gorges Dam 1,000 km east of Shanghai, and the massive expansion of container port facilities in Shanghai.

With the completion of the Three Gorges Dam, barges capable of moving 250 TEUs will be able to reach more than 2,400 km inland to Chongqing, as compared to the 144 TEU capacity barges in use currently. As river conditions continue to improve, it is foreseen that 300-400 TEU barges will operate on the Yangtze.

Barge companies the length of the Yangtze have begun experimenting with sea-going barges, which are deeper draft, higher-powered ships, capable of moving 250-300 TEUs at a time far up the Yangtze to ports as distant as South Korea and Japan.

In 2005, more than 2.6 mTEUs were moved by barge, a 44% increase over 2004, and up from just 604,000 TEUs in 2000. This figure is already approaching traffic levels on the Rhine and is growing at a much faster rate. The Yangtze River Navigation Administration estimated that 2006 container traffic will reach 3.1 mTEUs. Central and local governments are now investing with the goal of raising traffic to 4.5 mTEUs by 2010 and 15 million TEUs by 2030.

Yangtze Node Port: Chongqing

Chongqing, 2,150 km upstream from Shanghai has evolved into a major transportation hub. It is served by eight container barge companies operating a fleet of 110 vessels of all types, with 26 sailings to Shanghai per week. Capacity at the city's main container port, Jiulongpo, was expanded to 200,000 TEUs and throughput exceeded 170,000 TEUs in 2005.

Seasonal water levels at Jiulongpo vary by more than 15 meters. The port manages these circumstances through a system of container platforms and pulleys, as well as floating offshore cranes.

Beyond 2009, port authorities envision a modern, 500,000 TEU capacity port plugged into an intermodal network serving tens of millions of customers in Chongqing and its hinterlands in Sichuan and southwest China.

A second container port has been opened 10 km downriver from Jiulongpo at Cuntan. This port was built using the latest construction techniques. Three of the facility's five planned container ports, with a capacity of 280,000 TEUs are now fully operational, along with a 150,000 finished car port.

The river's average year-round depth, 4.5 meters (15 ft) at Chongqing, is sufficient to allow each berth's pair of new dockside cranes to unload barges directly into the container yard.

The 6,300 TEU capacity yard is adjacent to road and rail links. When the remaining two berths are completed in 2009, total capacity at the port's five berths will be 300,000 TEUs.

Cuntain will bring the total capacity for Chongqing's ports to nearly 1.5 mTEUs by 2010.This is more than double the throughput at Duisburg, the world's current largest inland container port, located on the Rhine River.

Construction of yet another container facility commenced in June 2005 at Changshou, 40km further downstream than Cuntan, at the site of a new chemical industrial park.

Yangtze Node Port: Wuhan

The other major industrial centre poised to benefit most from increased Yangtze traffic is Wuhan, 800 km downstream from Chongqing. Located midway between Chongqing and Shanghai, at the confluence of the Han River, the Yangtze's major tributary, Wuhan has evolved into one of China's transportation epicenters. The city's main container facilities are located at Hanyang Port. This port, which has three berths, two semi-automatic cranes, handled approximately 250,000 TEUs in 2006.

A second facility, 25 km downriver from Hanyang Port is expected to be completed in 2009. Situated directly next to new rail and expressway infrastructure, Yangluo New Port will be the largest container facility in the middle Yangtze.

This port's six berths will eventually add 1.2 mTEUs to Wuhan's port capacity. With an average water depth of seven meters it will also be able to accommodate 10,000 DWT ocean-going ships.

Comparative Shipping Costs

Comparative Transportation Costs & Transit Times
Yangtze River Basin

ROUTE	MODE	DISTANCE KM	TRANSIT TIME DAYS	COST/TEU USD	COST/KM USD	COST/TEU INDEX	TIME INDEX
1	Truck	2,150	3 - 4	1,584	.74	1.00	1.00
1	Rail	2,250	7 - 10	568	.25	.36	2.43
1	**Barge**	**2,400**	**8 (11 upriver)**	**330**	**.14**	**.21**	**2.71**
2	Truck	700	3	858	1.23	1.00	1.00
2	Rail	1,000	6	370	.37	.43	2.00
2	**Barge**	**1,280**	**4 (6 upriver)**	**290**	**.23**	**.34**	**1.67**
3	Truck	920	1 - 2	726	.79	1.00	1.00
3	Rail	1030	6	304	.30	.42	4.00
3	**Barge**	**1125**	**2 - 3**	**225**	**.20**	**.31**	**1.67**

Source: Deloitte research, industry sources

As can be seen from the table above, the economics of movement of containerized goods by barge on three of the Yangtze's major routes are favourable, compared to the rail and truck modes.

While transit time is considerably longer for barges, compared to truck or rail, the per TEU and per km cost is highly favourable. To illustrate, as of 2006, the cost of shipping a 20 ft. container the 2,400 km from Chongqing to Shanghai was approximately US$330, including port fees. The voyage takes eight days downstream, and 11-12 days returning.

By comparison, moving a container by road takes just 3-4 days, but the cost will not be less than 4-5 times as much to transport just 10 tons of freight. Moving containers by rail is approximately double that of river transport, but unexpected delays result in a 7-10 transit time. Also, unlike barge service GPS is not available to track goods in transit.

Government predictions are that the cost of moving containers by barge along the middle Yangtze will fall by roughly 35% by 2010. Logistics professionals predict price reductions to be in the 20% range. The reasons for this are competition from expanded services, and fleet upgrades resulting from increased competition.

In summary, China has seen the advantages of moving goods by river because of the lower costs involved. Transporting containers by river tends to take almost twice as long as transport by truck but is one third to one quarter as costly. The river method required few changes except the construction of node ports along the river.

8.2 The Rhine River Transportation Corridor

The Rhine River corridor stretches for 1,320 kilometers from the Alps to the North Sea[76], and encompasses an area of 465,308 km^2. It is considered to be one of the busiest waterways in Germany[77]. The river runs through France, Germany, Switzerland, Netherlands, and Luxembourg[78].

This corridor houses a population of 116 million people, with a waterway density of 30/1,000 km^2, and a population density of 250/km^2 - the highest waterway and population densities of all European river corridors.

Some 150 of the 334 so-called 'E-ports' are located in the Rhine corridor. The average distance between two adjacent ports is about 20km (port density). There are also a number of public ports which are not classified as 'E-ports', as well as several hundreds of private (industrial) ports and wet trans-shipment sites.

Rotterdam, Europe's largest logistics and industrial hub, is located at the mouth of the Rhine on the North Sea. It is the gateway to over 450 million consumers in the European market[79]. Antwerp is a second major deep-water port.

Rotterdam is a high traffic port partly because it can handle the new generation of post-Panamax ships without any restrictions. These large ships are able to enter the Port at anytime during the day, even at low tide.

[76] http://www.africanwater.org/rhine_main.htm
[77] http://www.germany.co.za/rhine_valley.html
[78] http://www.grid.unep.ch/product/publication/freshwater_europe/rhine.php
[79] http://www.portofrotterdam.com/en/facts_figures/port_description/index.jsp

Rotterdam has connections to five intermodal transportation services: road, rail, inland shipping, coastal shipping, and pipeline. This allows certain goods that are received at Rotterdam in the morning to arrive at their destination by the same afternoon.

Liquid bulk, such as crude oil, oil products, and liquid chemicals account for about half of the throughput at Rotterdam. The Rhine River is home to many production facilities, including 10% of the world's chemical production. It is also home to a variety of other industries, such as refineries, metal works, and plastics[80].

The Rhine River links with the Danube River, providing a transcontinental water route from the North Sea to the Black Sea[81]. Companies thus can ship goods from across Europe quicker, cheaper, and more conveniently.

Barges travel along the Rhine River to deliver containers. Some 5,500 dry cargo self-propelled ships are licensed to operate on the Rhine, with an average capacity of about 1,000 tdw (tonnes-deadweight). A little over one thousand tankers with an average capacity of about 1,500 tdw operate on the river.[82]

Barge pushing technology has remained relatively limited on the Rhine. Some 1,100 pushed barges for dry cargo, with an average unit capacity of about 2,000 tonnes, are nowadays certified for service on the Rhine.

A typical cargo ship on the Rhine has a length of between 80 and 110m, a beam of 9.5 to 11.4m, and a design draught that allows a loading of up to 2.8m. Larger craft can measure 134 meters long and 17 meters wide and carry up to 398 TEUs[83]. Even larger barges and ships can be accommodated, but geography and logistics, notably lock operation times and bridges that restrict container stacking to three[84], are constraining factors.

[80] http://www.bbc.co.uk/scotland/education/int/geog/eei/rivers/rhine/
[81] http://www.germany.co.za/rhine_valley.html
[82] PINE report - http://ec.europa.eu/transport/iw/studies/doc/2004_pine_report_report_concise_en.pdf
[83] http://www.tbm.tudelft.nl/webstaf/jann/git6.htm
[84] ibid

Operating and standby costs range, as of March 2004, between €5.00 and €7.00/tonne, depending upon capacity utilization.

The forecasted IWT volume by commodity type on the EU waterways by 2010 is:

Cargo Type	2010	2005	Increase
Containerized cargo	23.5	19.9	3.4%
General cargo	115.1	102.4	2.3%
Liquid bulk	80.1	74.9	1.3%
Solid bulk	185.6	270.8	0.9%
Total volume	**504.2**	**467.9**	**1.4%**

Transport volume on the Rhine-Upper Danube system is forecast to grow between 2000 and 2015 annually by a rate of 1.36% under the base scenario, and 7.12% under an optimistic scenario.

Relative Costs by Mode

The PINE report referenced a study of the shipment of 1.44 TEU on average from Rotterdam to Heidelberg for three modes, direct road, IWT, and rail requiring a road end-haul. The inland navigation solution was found to be 30% cheaper than rail and 27% cheaper than direct road on this route.

The short end-haul by road, including the terminal costs required, is more expensive than the long IWT haul. In this scenario, given the costs calculated, the rail alternative was hardly competitive with road and IWT, while the favourable starting position of inland navigation is negatively affected by the cost and waiting times of the intermediate processes (e.g. terminal transshipment)

Similarly, for shipments of liquid bulk from Rotterdam to Vienna, the journey with tanker trailers was found to be the most expensive, but also the fastest (two days door-to-door transit time). Rail transport using standard tanker containers would take four days and cost around 80% of the road alternative, whereas IWT only would be the cheapest but also the slowest option (eight days) because 66 locks would have to be passed.

A combination of IWT on the Rhine, with transshipment to rail for the final journey was found to reduce the transit time to approximately 5.5 days and result in a price only marginally lower than the rail-only alternative.

Over the past decade, there has been a growing interest in the concept of modal shift, transferring goods flows from one mode to another. Typically, this involves incorporating IWT into a sole road/rail haulage scenario.

Two main reasons are provided for this ‘shift’: road congestion relief and reduction of the negative effects of road transport on the environment. Several EU projects and studies came to the following conclusions:

- Inland waterway transport is well-equipped for modal shift
- The shifting of bulk cargo demands that both sender and recipient are situated near waterways. Any further pre-and post-transport of bulk by road usually turns out to be both expensive and inefficient. Building inland terminals could enable companies to use IWT.

New logistics concepts are currently being studied for implementation on the Rhine River. The aim is to further promote the use of inland water transport of goods.

These include:

- *Modal shifts* – transferring goods flows from one mode to another, e.g. IWT – rail/truck – to reduce road haulage.
- *Floating inventories* – shipping large batches of goods prior to the end-buyer being determined.

- *IWT transport of palletized goods* – consolidating small shipments in palletized "bundles" which lend themselves to efficient handling and trans-shipment.

- *Optimizing logistic chains* – collecting goods from different companies in order to obtain volumes which make IWT transport viable.

Despite the heavy utilization of the Rhine River, recent publications suggest the Rhine can absorb a seven-fold increase in transport activities.[85]

The PINE study also indicated that sufficient fairway conditions, notably on the Upper Danube, would have the following economic, social and environmental benefits:[86]

- Savings on *investments* in the road system
- Savings on *external costs* of transport, such as
    - Reduction of accident costs
    - Reduction of congestion costs
    - Reduction of CO2-emissions (Kyoto-objectives)
    - Reduction of noise
    - Reduction of space consumption

9.0 FRASER RIVER SHORT SEA SHIPPING

9.1 The Concept

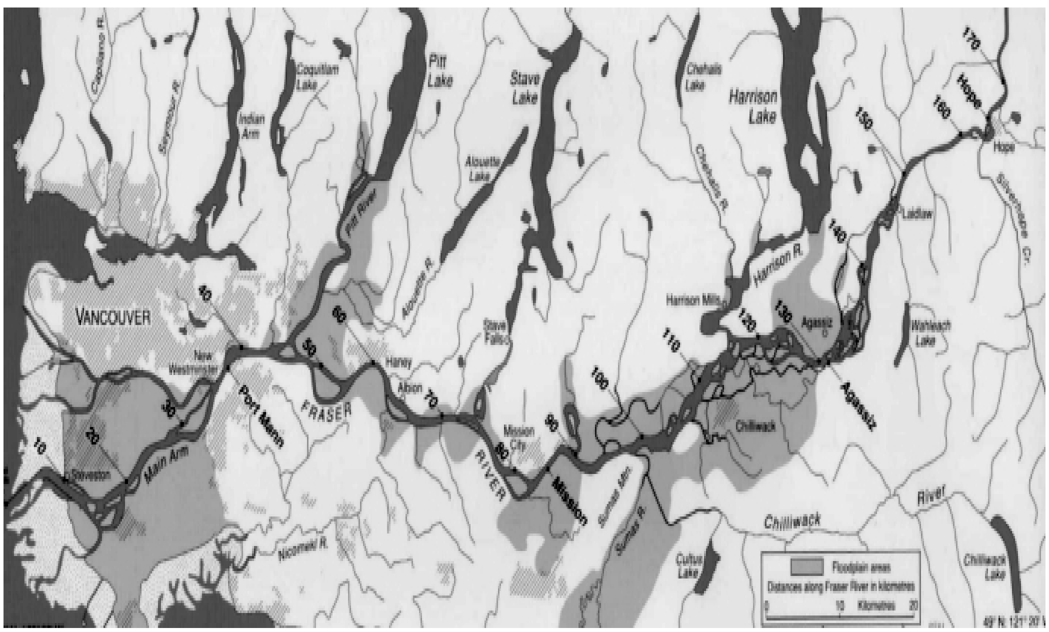
Short Sea Shipping on the Fraser River involves the transport of bulk and containerized freight between the deep sea port(s) and upstream node ports.

[85] "The power of Inland navigation, The social relevance of freight transport and inland shipping 2004-2005" – reported by the European Barge Union EBU, April 2007
[86] PINE study – reference by European Barge Union EBU, April 2007
http://www.dst-org.de/projekte/projekte/PINE/Pine-eng.htm#204

Goods are transported by suitable river vessels – motorized barges, or barges pushed/towed by tugboats. Node ports would be strategically located in proximity to existing rail lines and main highway networks (e.g. Highway 1).

Potentially, approximately 100 to 120 kilometers of the Lower Fraser River is suitable for river-based transportation. As can be seen from the map below, this would place the furthest upstream node port somewhere in proximity of Chilliwack and Agassiz.

A logical node port placement site would be at a location which has ready rail and highway access. Sumas would fit these criteria, in that a node port there would have ready access to Highway 1, and a rail link to USA ports of entry.



A typical Short Sea Shipping scenario would involve the transfer, at the tidewater port, of inbound shipping containers onto a barge which then travels upstream to node ports. There the containers are offloaded and then transferred to truck or rail for delivery to the consignee. The process works in reverse for outbound containers.

Each node port has a container yard for storage of full and empty containers. Adjacent to the property would be one or more warehouses and distribution centers, which cater to the needs of shippers and receivers.

Short Sea Shipping on the Fraser River would have as its objectives the establishment of a more efficient, diversified goods transportation system – one which strengthens the Lower Mainland economy. Reductions in road congestion and associated pollution would result from shorter average truck trip lengths and less idling-in-traffic times.

9.2 Potential Node Port Locations

The Gateway Council study's 2005 pre-feasibility report indicated the following factors need to be considered when surveying a potential node port location.[87]

- Physical Characteristics and Site Suitability:
    - Appropriate size for a SSS facility (e.g., minimum of ten acres)
    - Site suitability for minimum, moderate and optimum node concepts
    - Site preparation costs and issues.
- Accessibility Issues:
    - Shorefront suitability
    - Water frontage to tie up barges
    - Water depth
    - Potential for dredging, if needed
    - Proximity, access, and distance to major railways
    - Proximity, access and distance to major highways.
- Operational Issues and Suitability:
    - Travel time from short sea facility to deep-sea terminals
    - Ease of navigation in and around the site
    - Level of labor costs and issues (union and non-union)

[87] Greater Vancouver Short Sea Container Shipping Study p.23

  - Barge load/unload capabilities and issues
  - Intra-service centre flow capability (site configuration suitability)
  - Ability to support other related container operations
  - Existence of or potential for on-site rail and rail siding.

- Development Factors:
  - Land availability/cost
  - Planning, zoning and re-zoning issues
  - Site preparation costs and issues
  - Level of support from neighboring municipality
  - Environmental issues
  - Development cost level.

Eighteen possible node port locations were identified by the GVGC. Of these, 11 had been evaluated so far as to suitability.

The possible sites, grouped by the following geographical areas are (refer to Appendix C for characteristics of these node port locations):

The Lower Fraser River and North Arm area (includes the South & South Arm): Eburne; Mitchell Island; Tilbury Island- Chatterton; Tilbury Island- Seaspan; Coast 2000.

The Lower Central Fraser River area (from the Alex Fraser Bridge to the Port Mann Bridge): the Fraser Delta; Burnaby Big Bend; Queensborough; Annacis Island; Fraser Surrey Area; Fraser Surrey Van Isle; Brunette Creek and Canfor; Fraser Mills.

The Upper Central Fraser River area (from the Port Mann Bridge upstream to the Maple Ridge area): Parsons Channel; Barnston Island; Port Kells Area; Pitt Meadows.

The Upper Fraser River area (from the Maple Ridge area to Mission): Mission Foreshore

The Coast 2000, Fraser Surrey Docks Area, Port Kells/ Parsons Channel Area, Pitt Meadows Airport Area, and Tilbury- Seaspan are the priority site areas for becoming nodes in a short sea shipping initiative. These areas are mostly within a 20 minute drive to the largest container industry businesses and container off-dock facilities.

9.3 Short Sea Shipping and Land Demand

Node ports are *not* expected to have a significant impact, positive or negative, on the land requirements of the port operations themselves. Regardless whether node ports are established, the deep-water ports will need to add approximately 450 acres in order to meet forecasted operational requirements.

Some of the projected 983 acres of additional adjacent warehousing and distribution center land would likely be relocated adjacent to the node ports instead of in proximity to the tidewater ports.

The attraction for warehousing and distribution center operators will be lower land and labour costs since node ports would be located inland, in less densely populated areas.

The size of node ports would be determined by the role they are to perform – e.g. as a local terminus for freight, or as a transshipment facility.

Given that the Fraser River basin does not support a large population and industrial base, Short Sea Shipping would probably be only feasible if the node ports were established as multi-modal transshipment centers, connecting waterway transport to rail and truck services.

It should be noted that this is precisely the direction that a number of Rhine node ports (e.g. Duisburg and Cologne), are taking in order to be commercially successful.

9.4 Infrastructure Needs Associated With Short Sea Shipping

The location of node ports depends on the availability of riverside land, the proximity of the node port to commercial and industrial centers, and the traveling distance to major road/rail arteries.

The node ports would function as smaller versions of the major port terminals, and as such require warehousing space for the containers, and road and railway networks. Node ports are expected to handle up to 5,000 TEUs per acre per year.[88] A realistic size for a node port is at least ten acres, or 50,000 TEUs per year.[89]

Each node port could remove 50,000 TEUs from the current system or 2.5% of the annual traffic. This means that if 35% of the containers currently leave deep sea terminals by truck, each node port could eliminate as many as 17,500 daily truck trips from the congested downtown core and Delta each and every day.

Investment in a node port can be significant to the transportation infrastructure as the adjacent distribution centers, container servicing, warehousing and storage businesses require efficient access to the main road and rail networks.

The amount of land needed for supporting businesses (such as container storage facilities) differs depending on the type of business and inventory turnover rates. Current estimates suggest node ports would be ten or more acres in size.[90]

As the Rhine River experience indicates, short stage-length inland waterway traffic has been the mainstay of the short-sea-shipping industry for decades. However, in recent years, inland ports have established intermodal facilities which link barge to rail and trucks. This has been a highly successful endeavour for those inland port operators who have aggressively pursued this revenue source.

If one or more inland Fraser River node ports were established as intermodal facilities handling transshipment to rail and long-haul trucks, this would affect the current 65/35

[88] Greater Vancouver Short Sea Container Shipping Study - pg..16
[89] ibid
[90] Greater Vancouver Short Sea Container Shipping Study- pg.17

ratio of rail to truck traffic out of the deep sea terminals, increase throughput by the node port, make it financially more viable, and mitigate into/out-of-town truck and rail traffic, and associated pollution.

Because the facility's traffic volume would be increased as a result of it being an intermodal terminal, additional acreage would be required for operation of the node port, and for ancillary services.

9.5 Business Implications

Businesses that would be directly affected by a short sea shipping initiative include warehousing companies, container maintenance facilities, and importing and exporting businesses.

In the short run, these companies would incur startup costs to build new facilities near node ports. Operating costs would probably be lower, however, as land and labour costs in less densely populated urban areas are typically less. In the long run, these firms would benefit from traffic growth through the node ports.

9.6 Environmental Implications

Air Pollution

Transportation involves the use of energy, and energy consumption is linked to pollution. Inland water transport (IWT) was found to be linked, on average, with the lowest external costs (emissions of pollution and noise) of the three inland modes (road, rail, IWT).[91]

A comparative study of the environmental impacts of modes of freight transport in the St. Lawrence axis found that rail involved 1.4 times, and truck 7.6 times the emissions from

[91] PINE Study "Prospects of Inland Navigation within the enlarged Europe". http://europa.eu.int/comm/transport/iw/index_en.htm

marine transport.[92] Increased marine activity, attributable to short sea shipping, will invariably result higher emissions from this source but these will be more than offset by reduced road and rail transport.

Freight emissions per tonne-km – for carcinogens, 2007 truck have been found to be better than marine vessels; for green house gases marine is better than 2007 truck. Better fuel/engine technologies than the minimum standard for marine vessels are desirable if short sea shipping on the Fraser River is to be seriously considered.[93]

The type of fuel used, efficiency of the engine, age of the equipment, and the frequency of trips will ultimately dictate the emission levels associated with inland waterway transport.

At first glance, diverting truck traffic from main port terminals seems as though it will automatically reduce air pollution. Simply diverting traffic does not reduce air pollution. Trucks operating out of node port locations will continue to emit pollutants, as will those vehicles which continue to operate to/from deep-sea port locations.

An overall reduction in emissions is anticipated however, as time-in-traffic and travel distances are reduced. A secondary payoff in reduced emissions is due to the fact that trucks operating shorter distances, with less idle-time, will run cleaner and require less maintenance.

Traffic Congestion

Residents, businesses and the economy generally are negatively affected by traffic congestion. Congested roads result in increased travel time, trip variability, and travel distance as commuters seek alternate, but longer, routes.

[92] A Comparative Study of the Environmental Impacts of Modes of Freight Transport in the St. Lawrence Axis (November 2000) - SODES
[93] "Air Quality Considerations and Issues for Short Sea Shipping", Transport Canada Short Sea Shipping Workshop, Derek Jennejohn, Sept. 2003.

Travel distance and time is linked to fuel usage, probability of accidents and the cost of living. These costs are absorbed by households as a part of maintaining a livelihood.[94] A more elusive, but nevertheless legitimate cost implication associated with traffic gridlock is the value of one hour of lost personal time.

As a result of increased truck transit times, the efficiency of the distribution system, and indirectly the efficiency of businesses within the Lower Mainland, is eroded. Excessive transportation costs and commute times affects the distribution and cost of labour within the region, as individuals look for employment closer to home, or opt to relocate closer to work in a more densely populated and expensive part of the region.

The impact of traffic congestion is not only felt by manufacturers, who depend on the delivery of materials to the factory and goods to customers. Service and administrative operations are also affected, as these businesses receive materials and documents via freight transporters and commercial couriers.

The available options for firms - stocking more inventory, establishing satellite operations closer to regional hubs of customers, increased number of delivery trips, operations outside traditional hours of work – all lead to higher costs and lower profits.

A key benefit attributable to short sea shipping is the removal of trucks from the Lower Mainland road network. One 340 TEU carrying barge destined from Vanterm/Centerm to Sumas would result in at least 170 fewer truck trips into and 170 fewer truck trips out of the inner harbor terminals, via the most congested road traffic areas, per day.

Noise Levels

[94] pg. 40 *The Cost of Congestion to the Economy in the Portland Region*

Noise is an inevitable byproduct of industrial activity. Nevertheless, the noise profile of inland water transport is less than that of rail and truck. Compared to marine, rail is 1.4 times noisier, and truck 1.3 times.[95]

Residents in the neighbourhood of a node port would be subjected to higher levels of noise attributable to port operations and truck/rail traffic than is the case in the absence of such industrial activity.

Measures can, however, be taken in the construction of the node ports and enhancement of the surrounding road networks to reduce the effects of noise pollution.

Light Pollution

Node ports are large industrial areas, at least ten acres in size, and will operate much like mini-ports. Lights used to illuminate the facilities may contribute to increases in light pollution. The hours of operation, and the level of illumination at night will be the determining factors concerning the extent to which the adjacent areas are subject to light pollution.

Quality of Life Impact

The determining factors with respect to quality of life for nearby residents will be the truck and service vehicle traffic, and the extent of air, noise and light pollution associated with node port operations.

These factors would have an effect on residential property values, and could result in opposition, by citizens and municipalities, to the establishment of a node port in proximity to a residential area.

Accidents and Spills

The inland waterway transport industry has been found to have an impeccable safety record, relative to rail and truck – both in North America and in the European Union.

[95] A Comparative Study of the Environmental Impacts of Modes of Freight Transport in the St. Lawrence Axis (November 2000) - SODES

Compared to marine, rail and truck had 13.7 and 74.7 times the number of accidents, and 10.0 and 37.5 times the number of spills.[96]

Based on these findings, it is reasonable to assume that short-sea-shipping would have a favourable impact on transportation-related life and property loss, with attendant savings in insurance premiums for individuals and companies.

9.7 Operational Costs

This section provides a framework for outlining the broad categories of costs which occur when a container is moved through the transportation system.

Two scenarios were examined – moving a container from Delta Port to Chilliwack by truck, and a modified process involving a node port at Chilliwack. Other intermodal possibilities, such as transporting containers by rail, were excluded.

As a first step, the stakeholders associated with each scenario were identified.

To Chilliwack by Truck	To Chilliwack by Barge
Shipping Company	Shipping Company
Port/Terminal Operator	Port/Terminal Operator
Trucking Company	Trucking Company
Container Storage Firm	Container Storage Firm
Customer	Customer
	Barge Operator
	Node Port

Once the key stakeholders were identified, a swimlane diagram was used to map out the steps associated with each freight distribution approach (See *Appendix D* and *Appendix E*). Cost categories were then established (*Appendix F*), and these were subsequently assigned to each process step involved in the two scenarios (*Appendix G*).

[96] A Comparative Study of the Environmental Impacts of Modes of Freight Transport in the St. Lawrence Axis (November 2000) - SODES

It should be noted that this cost identification model is very basic and provides only a framework for further research. Little research regarding the operational costs associated with container movement appeared to be publicly available.

The Conventional "By Truck" Scenario

The container is offloaded from the ship and temporarily stored in the yard until a truck arrives to pick it up. The container is loaded onto the truck, which then transports it to the customer's location (or to a warehouse for disassembly). Empty containers are either delivered to a container storage facility, or returned to the port for outbound shipment.

From the customer's perspective, costs are associated with each part of the supply chain – trans-ocean shipping, container off/on-loading, container storage, and trucking to/from the final goods destination. The costs incurred vary, depending upon the nature of the service provided. However, each service provider will have capital and operating costs to charge back to the shipper/receiver.

The "Short Sea Shipping" Scenario

The container is offloaded from the ship and temporarily stored in the yard until a barge is available for transport upriver. The container is loaded onto the barge which then hauls it to the node port nearest to the container's final destination.

At the node port the container is loaded onto the truck, which then transports it to the customer's location (or to a warehouse for unpacking). Empty containers are either delivered to a local container storage facility, or returned to the node port yard for outbound shipment.

A basic tenet in freight transport is that the more often a freight item (e.g. a box or a container) is handled, the higher the cost. Short sea shipping does not eliminate the need for trucking (or rail); upon arrival at the node port the container still has to be loaded onto a truck (or a railcar), for delivery to the final destination. The extra steps involved – e.g. barging and barge on/off loading – ultimately add to the total shipping cost, which the customer will be required to absorb.

A reasonable assumption is that trucking costs will be lower with the SSS approach, as the transport-by-truck distance will presumably be less, however, the barging and node port handling costs will likely offset (or possibly even exceed) those savings.

The node port's cost structure will somewhat mirror that of its deep-sea port partner. It will be a capital intensive operation, involving the use of specialized equipment for loading and unloading containers on/off barges, trucks, and railcars. As is the case with tidewater ports, node ports will need surveillance and other security equipment to guarantee the security of cargo while in transit.

The barging company may need to acquire additional and/or different vessels than are in use on the Fraser River today. For example, the preferred inland waterway craft on the Rhine and Yangtze rivers are motorized barges, whereas the conventional transport mode on the Fraser River today is towed, non-motorized barges.

A stronger financial commitment will also be necessary from the Federal Government to underwrite the cost of dredging on the Lower Fraser River, if water depths to the proposed node ports are to be maintained year-round.

As is evident from this brief overview, further research into the economic viability of short sea shipping on the Fraser River is required in order to be able to establish the economic viability of this form of freight transport.

10.0 ASSESSMENT OF FEASIBILITY

On the surface, short sea shipping in the Fraser River offers limited possibilities. In comparison with the Rhine and Yangtze River systems, the Fraser River basin lacks the river corridor population and industry base for a self-sufficient inland water transport system.

Raw materials for export, such as lumber and grain, originate deep within the continent, rather than locally, and containerized goods are predominantly for/from Eastern Canadian and U.S. markets.

Nevertheless, it is worthwhile to examine the potential of the Fraser River as a transportation corridor from several perspectives – perspectives which reflect the international experience with inland water transport.

10.1 Modal Choice

The competitive situation of inland water transport (IWT), compared to other modes reflects the ability of inland navigation to match shippers' requirements. Both 'hard' and 'soft' factors determine which mode of transport is chosen by shippers.

'Hard' factors are based on rational calculations, such as weighing up the costs and quality aspects. Reliability, frequency, lead-time and flexibility are important aspects, but all factors are strongly related to total transport price.[97]

'Soft' factors reflect individual preferences that may arise from ingrained habits, prejudice, or lack of knowledge about alternatives. For many decision-makers, modal choice is limited to a decision of 'road' or 'rail', reflecting insufficient familiarity with the IWT option and in some cases, a matter of history or tradition.

Conclusions

The 'hard' factors for an inland waterway transport system on the Fraser River have as yet to be determined. Shipper preferences, the 'soft' factors, would take time to modify, and require a concerted communications effort to overcome built-in transport-mode biases.

10.2 Inland Water Transport Affinity

[97] PINE study, p.92

The relative affinity of IWT to types of commodities can be summarized as follows:

- goods shipped in large quantities;
- production sites located on waterways;
- goods to be transported to and from the hinterland of sea ports;
- goods transports that are not restricted by short time frames;
- goods of low value, especially in bulk, where IWT has a cost advantage;
- goods in containers;
- dangerous goods where the safety factor is paramount;
- machinery, vehicles, bulky agricultural machines, large building elements, transshipped with efficient Roll on/Roll off technology;
- goods on long distance intermodal transport where the cost advantage of long waterway transport can offset trans-shipment and pre-/end haulage costs.

A 'negative' list would include:

- small-sized shipments;
- time critical shipments, e.g. perishable goods;
- sensitive goods (paper, tropical fruits, goods sensitive to water or vibrations);
- goods carried in non-stackable transport boxes (swap bodies).

Conclusions

In examining these factors, the logical conclusion with respect to the Fraser River as an inland waterway is that bulk and break-bulk shipments are the best candidates for shipments on the Lower Fraser River. The proviso is that such shipments originate within the Lower Fraser River basin, rather than far in British Columbia's hinterland or in eastern provinces.

Bulk commodity transport by towed barge – wood products, aggregates, etc. – from the lower Fraser River Basin is already a fact of life. Trans-shipment of long-haul rail-transported commodities such as coal, sulphur, potash, and grain, is likely to not be feasible, considering the added cost associated with off/on-loading and barging under a multi-modal approach.

Trans-shipment of containers is a possibility, provided the IWT haulage costs from the deep-sea port to the node port are not excessive relative to direct rail/truck from the tidewater port, and provided the additional transit time is acceptable to shipping customers.

An intermodal Fraser River transport ‘solution’ to container shipping would provide a number of environmental benefits to Lower Mainland residents. Most notable would be reductions in:

- Truck traffic on road arteries, resulting from the transport of Lower Mainland destined containers to inland node ports, and truck traffic associated with the in-bound truck transport of bulk cargo and containers.
- Rail traffic on rail lines between the deep-sea and node ports.
- Lower Mainland air (and noise) pollution, attributable to reduced truck traffic on BC roads and reduced rail traffic on the sector between the deep-sea and node ports.
- Accidents involving trucks (and passenger vehicles) on BC roads.

Considering the Lower Mainland’s relatively small population and industrial base, river-based freight transport will likely play a relatively small role in the overall freight transportation system without an intermodal container shipment component.

Before a decision could be made with respect to the establishment of an intermodal container transportation system which includes an IWT element, a number of factors would need to be in place, including:

- A willingness and commitment on the part of the various public sector agencies, notably the Provincial and Federal Ministries and Departments, to seriously consider and examine the issue.

- Support, from the Lower Mainland port authorities, in the form of a willingness to consider an alternative to the current way of 'doing business'.

- Adequate funding to conduct a feasibility study which examines the economic, environmental and social costs and benefits associated with an inland intermodal freight transport system.

- The establishment of a multi-stakeholder transportation industry body to direct the research, and ultimately 'drive' the implementation of a viable transportation alternative.

- The 'up-front' involvement of various key stakeholders, such as the Fraser River Estuary Management Program (FREMP), the municipalities, and key environmental oversight groups.

10.3 Research Focus

Research into the Fraser River as a transportation corridor should include an examination of the feasibility of operating node ports as transshipment centers. As a minimum, the research activity should including the following areas:

Operating Implications and Costs

The costs associated with operating a stand-alone node port, and an intermodal transshipment facility; the supply-chain impacts (dollars, shipping time, etc.) of integrating an inland waterway transport component into the container shipment logistics system; the impact on deep-water port operations of establishing a node port transshipment center.

Infrastructure

The inland port infrastructure requirements, and associated costs, to be identified include the: number of berths; yard space; roadways; rail right-of-ways and; warehousing facilities. A second, critical aspect of this research is the associated river widening and dredging requirements.

Technology

The relative efficiencies of different types of river vessels; new developments in port/node port container handling equipment; information systems and security systems requirements.

Land Demand

The land requirements (and land costs) associated with the establishment of node ports at pre-determined locations under various traffic growth scenarios. Also the ancillary industrial acreage needed to accommodate a host of transport-related service providers, such as warehousing, container storage and maintenance, and import/export firms.

Local and Regional Environmental Impacts

The volume of road traffic; air pollution and noise generated by node port operations, truck and rail activity; water quality impact and implications for fish stocks; impact on local property values and quality of life for residents; road traffic congestion on the Lower Mainland major traffic arteries; commute times; road safety impacts and; air pollution within the Lower Mainland air shed.

Governance Issues

Jurisdiction, decision-making powers and overlaps may be considered deficiencies under the current governance system. International inland waterway governance structures, including their effectiveness and shortcomings, need to be examined in detail.

APPENDICES

Appendix A - Template Table of Contents

Source: *Potential Impact of Short Sea Shipping in the Southern California Region*, 2006

1. Introduction
1.1 Regional Freight Transportation Challenges
1.2 Short Sea Shipping Initiative

2. Marine Container Movements in the Southern California Region
2.1 Current Structure of West Coast Port System and Shipping Patterns
2.2 Container Volume Growth at SPB Ports

3. Potential Short Sea Shipping Services in the U.S. West Coast
3.1 The Concept
3.2 Possible Service Arrangements
3.3 SSS and Regional Port Systems

4. Southern California Port System and Targeted Markets
4.1 Southern California Ports
4.2 Potential Market Segments in Southern California
4.2.1 Growth of Empty Ocean Going Containers
    a. Increased Demand for Trans-loading
    b. Development of Warehouse and Distribution Centers Further Inland
4.2.2 International Movements to/from Manufacturing Areas in Northern Mexico

5. Integrated SSS Alternative for the Southern California Port System
5.1 Operational Analysis
5.2 Overall System Operation Example: North Bound Movement
5.5 Elements of Operational Costs
5.4 Congestion and Environmental Implications of the SSS Alternative

6. Conclusions

Appendix B – Potential for Node Ports[98]

Nodes	Description Ownership Environmental & Social considerations	Development Potential – Goods/Cargo	Development Potential - Passenger Terminal	Node serviced by Road? Rail? Combination	Other Considerations	Stakeholders Organizations involved in development
1. Fraser /Richmond Properties – Coast 2000 Terminal	680 acre former landfill site. Land administered by the Fraser River Port Authority for marine and Industrial uses. Environmental Issues in hand.	Development underway. Plans include a coastal and deep-sea terminal as well as serviced backup land for distribution related industry	No passenger capability	Road link to East – West Richmond Connector. CN Rail is on site now.	Land is available for lease from FRPA but no land sales available.	Fraser River Port Authority, CN Rail City of Richmond.
2. Tilbury Island	65 acre waterfront site. Owned by Stuart Belkin (Chatterton) Washington Group (Seaspan) Smit International (RivTow site) Environmental considerations on Chatterton site only.	Seaspan & RivTow sites are presently used for waterborne distribution. Expansion potential is at Chatterton.	Passenger service potential.	River Road connection is poor. Rail Service via CNR & BNSF	Old deep-sea bulk loading facility exists at Chatterton site.	Land owners Railways Corporation of Delta.
3. Fraser Surrey Area	Fraser River Port Authority. Zoned Industrial, Environmental Issues in hand	Deep sea Terminal (Fraser Surrey Docks) in place as well as 80 acres of distribution facilities. 20 acres waterfront optioned for water – dependant cargo distribution.	No passenger capability	Reasonable road access and on the future South Fraser Perimeter Road. Served by CNR, CPR, BNSF & SRY	Adjacent lands owned by the Province of BC 150 acres zoned industrial.	FRPA, City of Surrey Province of BC Southern Railway of BC CN Rail BNSF
4. Brunette Creek	The majority of the site is privately owned, with some GVRD ownership. Environmentally sensitive areas need to be considered.	Development potential requires further investigation	Passenger capability requires further investigation	Road access has network bottlenecks which create significant access constraints in some areas. Some properties are only accessible via North Road that presently has very low traffic. Further information would be required on port throughput and traffic generation from cargo. Partial rail access: may not be active (would need to be confirmed)	Soil contamination at Domtar site	Landowners Environmental groups, including Stream keeper groups City of Coquitlam GVRD FREMP CP Rail
Nodes	Description Ownership Environmental & Social	Development Potential – Goods/Cargo	Development Potential - Passenger Terminal	Node serviced by Road? Rail? Combination	Other Considerations	Stakeholders Organizations involved in development

[98] Greater Vancouver Gateway Council - Major Commercial Transportation System p.9

	considerations					
5. Port Kells	Area Approx. 20 acres on triangular site bordered by Fraser River, Triggs Road and 104 Ave. Properties owned b y T e a l Cedar Products and Columbia Shake & Shingle. Site is mostly coded "Green"	Eroded foreshore and excavated log pocket could provide "end on" moorage (i.e. ferry style) for limited impact on navigation.	Potential water based passenger service fed by #1 Freeway or future rail passengers from a CN like "West Coast Express"	Close access to 176th Street that leads to #1 Freeway. Close access to CN mainline. Very close to the proposed South Fraser Perimeter Road	Adjacent lands are mill and/or wood fiber oriented. Could be available if pressure on BC forest industry continues. Currently processing high value cedar products.	Land owners City of Surrey CN Railway
6. Pitt Meadows Airport	Owned by the Pitt Meadows Airport Society, Municipality of Pitt Meadows and Maple Ridge Much of the land is contained within the ALR. Land is located within the flood plain so development costs could be high.	Airport Society motivated toward industrial development. Good deep water site.	Existing air passenger terminal. Potential links to rail and water passenger service.	Limited road access at present but proposed Fraser River Crossing will be nearby. CP Railway is close by as is CPR Intermodal Yard.	Difficult to rezone from current ALR designation. Limited availability of inexpensive fill material.	Pitt Meadows Airport Society Cities of Pitt Meadows and Maple Ridge. CP Rail
7. Burnaby Big Bend	City of Burnaby Severe environmental remediation on going		None	Serviced by road and CN Rail	Movie Studio enquiries	
8. Mitchell Island		Available space to develop	None	Serviced by road and water	None	
9. Eburne	Site Owned by NFPA No environmental considerations	Potential for Container Terminal	Potential for Passenger Terminal	Serviced by road and CP Rail	None	
10. Fraser/ Delta Area	Several small parcels owned by a number of owners. Fraser River Port Authority owns 15 non-contiguous parcels equal to approx. 50 acres.	Potential Industrial site, CFS/CY yard No direct access to water as River Road runs between river and property.	Possible passenger terminal but not if River Road continues in its present location.	Serviced by CN/BNSF	Site needs to be consolidated. This was a Fraser River Port Authority goal prior to the enactment of the Canada Marine Act.	Fraser River Port Authority The Corporation of Delta Various small lot owners
11. Mission Industrial Foreshore	Mission Raceway and adjacent industrial lands. Ownership not yet determined Flat, developable land on river-front. Land is in the floodplain and flood proofing requirements unknown. Race track may have to be relocated River in area of productive fish habitat.	Good access to river for all types of cargo.	Currently adjacent to the eastern terminus of the West Coast Express. Could this be an alternative passenger mode?	CPR mainline adjacent, CNR can cross from south shore via CP Bridge. Lougheed Highway near by, good access to the Mission Bridge, # 1 Freeway and US Border.	Much of the site is Mission Raceway. This is a positive in that it holds the lands but by the time conversion takes place there may be little opportunity to relocate the raceway.	City of Mission CP Rail

Appendix C - Fraser River Stakeholder Concerns

Public Sector Stakeholders	Economic Growth Intl Trade	Infrastructure Costs, Expansion	Tax Base	Traffic Volumes, Pattern Changes	Air/Water/Noise Pollution	Fish/Aquamarine Habitat Protection	Fish Stocks, Harvest	Recreational Impacts	Real Estate Values	Land Claims
FAIT	X	X								
Min. Economic Development	X	X								
Min. Highways		X		X						
Transport Canada		X		X	X					
Min. Finance		X	X							
Municipal/Regional Goverments	X	X	X	X	X			X	X	
First Nations					X	X	X			X
Environment Canada					X	X		X		
Fisheries Oceans Canada					X	X	X			
Min. Environment					X	X	X	X		

Appendix C (continued)

Private Sector Stakeholders	Infrastructure Costs, Expansion	Cargo Transit Time	Cargo Transport Costs	Competitiveness	Loss/Gain of Business	Proximity to Local Customers	Environmental Impacts	Recreational Impacts	Real Estate Values	Job Security, Compensation
Port/Terminal Operators	X	X	X	X	X		X			
Shipping Companies		X	X	X						
Shippers/ Receivers		X	X	X		X				
Railway Companies	X			X	X					
Trucking Companies	X			X	X					
Labour Unions					X					X
Local Residents							X	X	X	
Local Businesses					X				X	
Environmental Groups							X	X		
Recreational Groups							X	X		

Appendix D - Sample Process: From Deltaport to Chilliwack by Truck

Role	Phase One	Phase Two	Phase Three	Phase Four
Customer (orders & receives goods)				Hires trucking company to pick up container
Shipping Company/Vessel	Vessel arrives at port terminal	Stands by as vessel is unloaded	Exits harbour for next port of call	
Delta Port	Assigns appropriate fees to shipping company	Unloads containers onto port acreage	Leaves container on acreage until trucking company picks up container	Sends Alberta/US bound containers out of Port jurisdiction by rail
Trucking company				Sets up equipment for pickup of container
Container Storage Firm				
	Phase Five	**Phase Six**	**Phase Seven**	**Phase Eight**
Customer			Receives widgets from trucking company	
Shipping Company				
Vancouver Port	Uses specialized equipment to load flatbed truck with container			
Trucking company	Picks up container at Vancouver Port	Drives to customer (destination)	De-stuffs container at customer location	Drives to container storage firm (Phase Nine) **or** back to Vancouver Port immediately (Phase Twelve)
Container Storage				

Appendix D (continued)

Role	Phase Nine	Phase Ten	Phase Eleven	Phase Twelve
Customer				
Shipping Company		Notifies storage firm and trucking company of next departure		
Delta Port				
Trucking company	Drops off container at storage firm	Drives back to storage firm	Loaded with empty container	Drives to Delta Port
Container Storage Firm	Inspects, maintains, and repairs container		Loads empty container onto flat bed truck	
	Phase Thirteen	**Phase Fourteen**	**Phase Fifteen (Termination)**	
Customer				
Shipping Company		Vessel is loaded with empty and filled containers	Sails to next destination with full load of containers	
Deltaport	Assigns appropriate fees to shipping company; unloads container from truck	Loads empty container onto vessel with the other waiting containers	Prepares for next group of containers	
Trucking company	Truck is unloaded at the port			
Storage Firm				

Appendix E - Modified Process using Node Ports: Delta Port to Chilliwack

Role	Phase One	Phase Two	Phase Three	Phase Four
Customer (orders & receives goods)				Hires trucking company to pick up container *at node*
Shipping Company/Vessel	Vessel arrives at port terminal	Stands by as vessel is unloaded	Exits harbour for next port of call	
Delta Port	Assigns appropriate fees to shipping company	Unloads containers onto port acreage	Leaves container on acreage until trucking company picks up container	Sends Alberta/US bound containers out of Port jurisdiction by rail *Sends node-bound containers to loading area*
River Barge				
Node Port				
Trucking Company				
Container Storage Firm				
	Phase Five	**Phase Six**	**Phase Seven**	**Phase Eight**
Customer				
Shipping Company/Vessel				
Delta Port	Uses specialized equipment to load barge with container(s)			
River Barge	Loaded at port(s)	Goes upriver	Stops at node ports along the way to drop off cargo	Stops at node port in Mission
Node Port				Receives barge
Trucking Company				
Storage Firm				

Appendix E (continued)

Role	Phase Nine	Phase Ten	Phase Eleven	Phase Twelve
Customer			Receives widgets from trucking company	
Shipping Company/Vessel		Notifies storage and trucking company of next departure		
Delta Port				
River Barge				
Node Port	Uses specialized equipment to load container onto flat bed truck			
Trucking Company	Picks up container at node	Drives to customer (destination)	De-stuffs container at customer location	Drives to container storage firm or back to node port immediately
Container Storage Firm				
	Phase Thirteen	**Phase Fourteen**	**Phase Fifteen**	**Phase Sixteen**
Customer				
Shipping Company/Vessel		Notifies storage and trucking company of next departure		
Delta Port				
River Barge				
Node Port				Receives barge
Trucking Company	Drops container off at container storage firm	Drives back to container storage firm	Loaded with empty container	Drives to node port
Storage Firm	Inspects, maintains and repairs containers		Loads empty container onto flat bed truck	

Appendix E (continued)

Role	Phase Seventeen	Phase Eighteen	Phase Nineteen	Phase Twenty
Customer				
Shipping Company/Vessel				
Delta Port				Unloads container from barge
River Barge		Barge is loaded with empty container	Barge floats back downriver to Delta Port	Barge is unloaded
Node Port	Unloads container from truck	Loads barge with empty container		Receives barge
Trucking Company	Drops container off at node port			
Container Storage Firm				

	Phase Twenty-One	Phase Twenty-Two	Phase Twenty-Three
Customer			
Shipping Company/Vessel		Vessel is loaded with empty and filled containers	Sails to next destination with full load of containers
Delta Port	Assigns appropriate fees to shipping company	Loads empty container onto vessel with the other waiting containers	Prepares for next group of containers
River Barge			
Node Port			
Trucking Company			
Storage Firm			

Appendix F - Operational Cost Categories

Inventory	Holding cost, rental space, obsolescence, shrinkage, opportunity cost, moving costs, building (if applicable)
Operations	Variable and fixed: Fuel, maintenance, indirect materials and other indirect costs including management salary, taxes; utilities, rental expense, insurance
Regulatory fees	Fees charged by regulatory bodies such as the Government of Canada, the BC Provincial Government, and local port authorities, licenses and permits, tariffs
Service charges	Fees charged by other firms for services rendered
Capital Cost	One time cost allocated over multiple periods: Salvage, depreciation, purchase of equipment
Wages	Fees charged by the firm's personnel—piecework or by the hour. Labour agreements affect this cost and trends in wages must be considered in any forecast of future conditions

Appendix G - Operational Cost Categories by Transport Phase

Transport from Delta Port to Chilliwack by Truck

	Inventory	Operation	Regulatory Fees	Service Charges	Capital Costs	Wages
Phase 1	SC	DP, SC	SC		SC	DP, SC
Phase 2	SC	DP, SC			DP, SC	DP, SC
Phase 3		DP, SC			DP, SC	DP, SC
Phase 4	DP	DP, TC		C	DP, TC	DP, TC
Phase 5	DP	DP, TC			DP, TC	DP, TC, C
Phase 6		TC	TC		TC	TC
Phase 7	C	TC, C		C	TC, C	TC, C
Phase 8		TC	TC		TC	TC
Phase 9	SF	TC, SF			TC, SF	TC, SF
Phase 10	SF	TC	TC		TC, SF	TC, SF
Phase 11		TC, SF			TC, SF	TC, SF
Phase 12		TC	TC		TC	TC
Phase 13	DP	TC			DP, TC	DP, TC
Phase 14		TC				
Phase 15						

Modified Process Using Node Port: Transport from Delta Port to Chilliwack

	Inventory	Operation	Regulatory Fees	Service Charges	Capital Costs	Wages
Phase 1	SC	DP, SC	SC		SC	DP, SC
Phase 2	SC	DP, SC			SC	DP, SC
Phase 3	DP	DP, SC			DP	DP
Phase 4	DP	DP	C		DP	DP, C
Phase 5	RB	DP, RB			DP, RB	DP, RB
Phase 6	RB	RB			RB	RB
Phase 7	RB	RB			RB	RB
Phase 8	NP	NP			NP	NP
Phase 9	TC	TC, NP	TC		TC, NP	TC, NP
Phase 10	TC	TC			TC	TC
Phase 11	C	TC, C		C	TC, C	TC, C
Phase 12		TC			TC	TC
Phase 13	SF	TC, SF			TC, SF	TC, SF
Phase 14		TC, SF			TC, SF	TC, SF
Phase 15		TC			TC	TC
Phase 16		TC			TC	TC
Phase 17		TC, NP			TC, NP	TC, NP
Phase 18	RB	RB, NP			RB, NP	RB, NP
Phase 19	RB	RB			RB	RB
Phase 20	RB	DP, RB			DP, RB	DP, RB
Phase 21		DP, SC				DP
Phase 22	SC	DP			DP, SC	DP, SC
Phase 23	SC				SC	SC

DP = Delta Port, SC = Shipping Company, C = Customer, TC = Trucking Company
SF = Container Storage Firm, RB = River Barge, NP = Node Port

Appendix H - Common Air Contaminants

Name	Source	Characteristics	Human Health Implications
Carbon Monoxide (CO)	Transportation: motor vehicles; industrial fuel-burning sources	Colourless and odourless	• Reduces ability of blood to carry oxygen to vital organs • Impaired performance, respiratory failure, and death
Nitrogen Oxides (NO_x)	High burning fuels in engines and boilers	Can react with other chemicals to form ozone, acid rain, and secondary particulate matter	• Irritates the lungs • Lowers resistance to respiratory infections
Volatile Organic Compounds (VOC)	Vegetation, motor vehicles, chemical plants, industrial/commer-cial/consumer solvents	Can react with NO_x to form smog	• Possible carcinogenic and toxic effects
Sulphur Oxides (SO_x)	Released when fuel burned	Can react with other chemicals to form ozone, acid rain, and secondary particulate matter	• Effects on breathing, escalation/aggravation of cardiovascular and respiratory disease, death
Inhalable Particulate Matter (PM_{10})	Transportation, dust, fuel burning, coal and grain handling industries	Each particle is 1/5th of the width of a human hair and	• Can be inhaled into the lungs
Fine Particulate Matter ($PM_{2.5}$)	Transportation, dust, fuel burning, coal and grain handling industries	Scatters light and visibility in the atmosphere	• Inhaled deep into the lungs • Premature death, aggravated asthma, acute respiratory symptoms, chronic bronchitis
Road Dust	Deposits on the road surface	Affected by wind and traffic movement—will move and redeposit	Inhalable particulate composed of various chemicals
Ammonia (NH_3)	Animal housing operations, wastes, fertilizer	Colourless with a sharp odour	Can combine with others to make particulate matter; irritant to skin and eyes in large quantities

Appendix I - Common Greenhouse Gases

Name	Source
Carbon dioxide (CO_2)	• Burning of fossil fuels, solid waste, and wood products
Methane (CH_4)	• Emitted during production and transport of natural gas • Decomposition of organic waste in landfills • Livestock
Nitrous Oxide (N_2O)	• Burning of solid waste and motor vehicle fuels • Emitted during agricultural and industrial activities

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