SITE Centre For Applied Research

# Truck or Barge?

## Comparative Analysis of Short Sea Shipping and Trucking in the Lower Mainland Transportation Corridor

*This report supercedes an earlier document prepared by Michael Woolley and colleagues.*

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# Executive Summary

As a gateway for freight traffic to Central and Eastern Canada and the United States, Port Metro Vancouver faces both opportunities for economic growth and significant challenges, not the least of which is difficulties associated with the efficient movement of goods across the population-dense Lower Mainland region.

Rapid urbanization and associated growth in vehicle traffic has significantly strained the existing road network. As well, land for new road and commercial development, particularly close to tide-water, is at a premium.

At present, containerized freight goods are transported by either rail, or 5 axle semi-trailer trucks. A third option exists, namely, to move the goods inland by tug/barge to a transfer point which is accessible to the TransCanada Highway and Rail Network. This option, prevalent on the Rhine River, has the potential of providing both economic and environmental benefits to British Columbians.

This study has attempted to answer the question “Truck or Barge?” for the transport of containerized goods across the Lower Mainland. The research has provided a number of important key insights for freight transporters and public policy makers, namely:

- Short-Sea-Shipping (SSS), the transport of goods along the Lower Fraser River, is more than competitive with trucking. It does however require a reasonable length route distance – for purposes of this study, the two transport nodes selected were Delta Port and Sumas (184 km by road, 164 km by river round trip).

- As trip duration time increases due to road traffic congestion, trucking becomes far more costly than the Short-Sea-Shipping alternative.

- Further economies of scale, and thus reduced transport cost/container, are achieved with higher capacity tug/barge equipment. This study examined two marine transport configurations: 200 TEU (100 40 ft containers), and 400 TEU vessels.

- Substantial operating cost and environmental savings are achievable using long-combination vehicles (LCVs) on roads instead of conventional semi-trailer trucks.

- Marine transport is far more “environmentally friendly” than truck transport, as a far lower tonnage of pollutant emissions are generated.

- Road transport of freight containers involves substantial public costs in terms of degradation of roadway pavement. Whereas the use of LCV trucks results in a 26 percent ESAL-km (a measure of roadway wear-and-tear) reduction. In comparison, the Short-Sea-Shipping option achieves a 100 percent reduction over the use of conventional semi-trailer trucks.

- Depending upon the dollar value of fleet and inland terminal investments required, and anticipated growth in container traffic volumes, such investments offer an internal rate of return of between 3% and 13%, and a payback of between 8 and 15 years.

- Efficiency gains are possible through fleet modernization (reduced fuel consumption) and inland transfer terminal automation.

# Terminology

**Barge:** A capacious, flat-bottomed vessel, usually intended to be pushed or towed, for transporting freight.

**Berth:** Sufficient space for a ship to maneuver; a space for a ship to dock or anchor.

**Bomb carts:** Chassis used to move containers within a terminal; are simpler than over-the-road chassis. They do not need to have brakes or lights and employ simple corner brackets to hold the container in place.

**Congestion Costs:** The cost incurred to a system due to a crowding effect, which leads to a strain on the capacity of the system. On roadways, congestion costs occur in the form of time delays, the idling of vehicle engines, and the external effects on the environment. After a certain point, an increase in traffic flow comes about with a decrease in the average speed of the vehicles within that flow. The slower speed raises the cost of the trip. There is thus a negative relationship between speed and flow on the one hand and speed and cost on the other.

**Dredging:** An excavation activity usually carried out at least partly underwater, in shallow seas or fresh water areas with the purpose of gathering up bottom sediments and disposing of them at a different location. This technique is often used to keep waterways navigable.

**Freshet:** A spring thaw resulting from snow and ice melt in the rivers located in the northern latitudes of North America, particularly Canada, where rivers are frozen each winter and thaw during the spring.

**Short Sea Shipping (SSS):** A marine movement of freight along coastal and inland waterways.

**Stevedoring:** To load or unload the cargo of (a ship) or to engage in the process of loading or unloading such a vessel.

**Traffic congestion:** Road network conditions which result from increased use. Reduced speeds, longer trip times, and vehicle queuing are all traffic congestion characteristics.

**Transportation Nodes:** The beginning and end points for transportation between geographic areas. They serve as access points to a distribution system or as transshipment locations within a transport network. This function is mainly serviced by transport terminals where flows originate, end, or are being transshipped from one mode to the other.

**Trans-shipping:** The movement of freight over one or more transfer points. The goods are switched from one vehicle to another as in the case of transferring containers from ocean vessels onto flatbed railcars.

**Twenty-foot equivalent unit (TEU):** A measure used for capacity in container transportation.

**Utility Tractor Rig (UTR):** Used to move containers around the yard.

**Wharf:** A structure built on the shore of/or projecting into a harbour, stream, etc.., so that vessels may be moored alongside to load or unload or to lie at rest; quay; pier.

**Yard Tractor Rig (YTR):** Trucks used in moving trailers and containers short distances around freight terminals, port facilities, warehouses, etc.

# Introduction

*Containerized growth expected to double in the next few years*

The growth in Canada's trade sector has necessitated research into viable alternatives to the conventional road transportation delivery mode. The World Trade Organization reports that Canada's imports and exports value have changed by 13% and 18% in the last seven years (World Trade Organization, 2013). Combined with the fact that in recent years about 20% of all goods through the Pacific ports are containerized, with this value expecting to double, implies that moving forward in the current model will cause increasing strain on local roadways and also a rise in emissions (Port Metro Vancouver, 2013).

The effects of this national growth are already observable at Port Metro Vancouver (PMV). PMV is the fourth largest tonnage port in North America (Port Metro Vancouver, 2013) and their operations have a significant impact on the BC economy. PMV employs 129,500 people and the container traffic and associated logistics contributes 1.2 billion to the economy.

*Expected growth in containerized traffic >6%/year*

In 2011, PMV reported 3,024 foreign vessels arriving in the ports and expected this value to increase to 3,236 by 2012. They also observed that containerized traffic volume increased by 6.3% over the period of 2010 to 2011 (Port Metro Vancouver, 2011). Ensuring that PMV operations are able to keep pace with the growth in demand is vital to securing expected future revenue.

## Nature and Scope of Study

This report evaluates the current semi-trailer truck transportation method used to transport freight containers in the PMV area and assesses alternative options, such as the long-combination-vehicle trucks and barging. Past reports have mainly focused on operating costs and have dismissed alternative options as being not economically viable.

This report differs in that environmental benefits (i.e. emission reductions) are quantified and incorporated into the cost-benefit analysis. Other considerations, such as technological innovation and industrial growth, will also be incorporated in the analysis.

## Assumptions and Exclusions

The following assumptions are made for the purpose of this study:

- Only containerized cargo will be evaluated for the purpose of this study (transportation of automobiles, break bulk cargo, or bulk cargo are not considered)

- The report does not take into consideration any political aspects, particularly regarding jurisdictional issues or decision requirements by municipal, provincial or federal elected bodies, but does explore the association of maintaining costs of current infrastructure.

## Methodology

The economic and environmental impact values are generated from a dynamic Excel model designed by the BCIT SITE Centre. The model allows for a comparison of different transportation modes, multiple scenarios, and modification of assumptions.

The inputs for the model are derived from consultations and interviews with local business representatives associated with container movements and a variety of publicly available material sourced online. Significant weight was given to material sourced from Government run websites. The following are sites that have been referenced[1]:

- Port Metro Vancouver
- Deltaport Authority
- TSI Daily Tracking
- Transport Canada, Government of Canada
- Ministry of Transportation, Government of BC.

# Port Metro Vancouver Background

PMV is the closest major North American port to Asia and is the principal authority for shipping and port related land and sea use in Metro Vancouver. It oversees the operations of many different enterprises including, but not limited to, cargo terminals, tugboats, trucks, railways, shipping agents, and freight carriers.

[1] Refer to references for the complete list of sources

The GVRD infrastructure is currently sufficient to support the level of TEU handling and transport activities. The expansion of the Deltaport, the Port Mann Bridge, and the completion of the South Fraser Perimeter Road have all contributed to improving the movement of TEUs through the region.

## PMV Economic Impact

Containerized operations at PMV are responsible for 11,100 person years[2] of direct employment. Container traffic is also directly responsible for contributing $1.2 billion to the economy. Accounting for the multiplier effects[3], both these values are expected to rise by about a rate of two.

Below is a table summarizing the resulting employment in person years and GDP from containerized operations attributable to containerized operations. Wages and economic output are also included as additional economic performance indicators. All total values at the bottom of the Table 1 incorporate the multiplier effect.

*PMV contributes to 27,200 person years of employment and 2.6 billion to GDP*

*Table 1: Economic impact of Port Metro Vancouver on BC*

| | Person Years | Wages ($Millions) | GDP ($Millions) | Economic Output ($Millions) |
|---|---|---|---|---|
| Direct | 11,100 | $630 | $1,200 | $2,750 |
| Indirect | 12,000 | $590 | $1,090 | $2,170 |
| Induced | 4,100 | $260 | $320 | $550 |
| **Total** | **27,200** | **$1,480** | **$2,600** | **$5,470** |

*Source Data: 2012 Port Metro Vancouver Economic Impact Study (Port Metro Vancouver, 2012)*

## Port Operations and Facilities

There are currently 28 cargo terminals, five of which handle containerized traffic in PMV. Table 2 lists the five terminals and their storage capacity.

[2] A person year is measured as the average amount of work done by a person in a year.
[3] The multiplier effect is a chain reaction causing indirect and induced impacts to lead to a greater increase in the economy then the initial amount generated.

*Only four of the 28 terminals handle containerized traffic in PMV*

*Table 2: BC cargo terminals with containerized traffic abilities*

| Terminal | Location | Berths | Storage Capacity |
|---|---|---|---|
| **Centerm** | Burrard Inlet | 6 | 12,000 TEUs |
| **Vanterm** | Burrard Inlet | 2 | 10,332 TEUs |
| **Fraser Surrey Docks** | South side of the Fraser River in Surrey | 7 | 8,000 containers |
| **Delta Port** | Delta near the mouth of the Fraser River | 3 | 41,250 TEUs |

*Source Data: Greater Vancouver Short Sea Container Shipping Study (NOVACORP International, 2005) and Vancouver Port Authority (Vancouver Port Authority, 2013)*

PMV also has 26 dockside gantry cranes, of which three are the new quad-lift technology cranes, the most advanced technology in North and South America. Delta Port terminal has recently added a third berth to its facilities enabling more access for containerized freight that will be arriving via the next generation of ships such as the Post Panamax Plus and New Panamax vessels.

## Road Network

A commonality among the various road networks used by the transportation industry is the high regular levels of congestion. According to traffic data captured by the Ministry of Transportation 1,400 truck movements were observed at the intersection between Highway 99 and Highway 17 during peak hours[4]. Other congestion examples include the Massey Tunnel usage, which has been over capacity for 13 hours a day since 1991. (Ministry of Transportation and Infrastructure, 2013)

## Fraser River Potential

The Fraser River is the longest river in British Columbia and commercial use of the river is concentrated in the lower Fraser River area (southern portion). Companies such as *Seaspan* have continued to use the river extensively in their operations for the movement of bulk goods, such as construction goods, pulp and paper, and lumber and steel.

At its current state, the Fraser River lacks established facilities along its length to handle large quantities of containerized freight. The Surrey Fraser dock is the only facility with the ability to handle limited containerized traffic.

[4] Between 07:00 to 08:00 hours

# Overview of Short Sea Shipping

SSS is a new transportation mode, but has established operations in a number of international jurisdictions, including the Rhine River, Yangtze River, Mississippi River and the St. Lawrence Seaway. These locations have already demonstrated positive economic and environmental results. The benefits and challenges associated with SSS are only derived from these established operations; expansive research in this section was not undertaken since this was not the report's principal mandate.

## Economic and Environmental Benefits of SSS

The benefits attributable to SSS can be categorized into economic (operating and efficiency) and environmental benefits. The former are measured as direct and indirect cost savings derived from SSS. The environmental benefits are measured as the emission reductions[5] from SSS. The benefits are summarized in Table 3 below.

*Table 3: SSS Economic and Environmental Benefits*

| | |
|---|---|
| **Economic Benefits** | |
| Increasing returns to scale operations | The nature of SSS operations requires a high fixed capital requirement, but involves relatively low operating costs. As capacity increases, the average costs per kilometer and per TEU decrease. |
| Reduction in public sector infrastructure expenditures | SSS requires lower infrastructure maintenance costs relative to the investments of new road networks and maintenance of old road networks by municipal and provincial governments. |
| Reduction in port congestion | SSS storage ability decreases the number of containers that need to be stored at sea side facilities, such as Deltaport, which allows for additional cargo to be delivered at the ports. |
| **Environmental Benefits** | |

[5] Emissions include carbon oxides ($CO_x$, nitrous oxides ($NO_x$), sulphur oxides ($SO_x$), hydrocarbons (HC), volatile organic compounds (VOCs), and particulate matter (PM).

| | |
|---|---|
| Reduction in road congestion | Transporting goods using SSS reduces the number of container truck trips. This contributes to reducing road congestion and associated road wear-and-tear. |
| Reduction in carbon emissions | Per TEU, SSS produces less carbon emissions than transport by truck |

Additional societal benefits attributable to SSS have been identified, but not listed in the table above as they are difficult to quantify:

- Improved road safety due reduced large vehicle traffic on roadways
- Reduction in noise pollution in urban areas.

## Challenges of SSS

**Physical Capital Requirements**

Establishing a SSS operation requires investment in land and equipment. Based on a previous study, SSS requires a minimum of 10 acres of land for a barge terminal facilty. When storage and other related storage container business operations are also considered, this number can increase up to 28 to 70 acres (NOVACORP International, 2005). This may present a challenge for developers as not all river-adjacent land may be zoned for commercial use.

Deep-sea terminals are typically configured with quay cranes, top-pick or reach stackers, yard tractor rigs, and bombcarts. The number of pieces and types of equipment required depend on the unique characteristics of each terminal and the throughput volume. Other factors affecting equipment requirement include water frontage, type of wharf, and form of loading, are applicable to all terminal types.

SSS terminals are not as complex as deep-sea terminals in terms of operations and volumes. For this reason, investment in equipment for SSS terminals is not as substantial. Initial research has indicated that reach stackers, yard top-pick, utility tractor rig, and bombcarts, are typical in the inventory of SSS terminals.

**External Challenges**

Beyond the challenges of establishing a SSS operation, the following has been identified as external challenges which can affect operating costs, efficiency of operations, and emissions:

- **Sediment buildup:** Sediment build up causes the river to become too shallow for navigation. It also creates difficulty for marine vessels to access waterways and channels.

- **Tidal patterns:** Changes in water levels impacts dock location, dock type, and vessel configuration decisions.

- **Freshet flows:** Freshet flows impact the river's tide and current conditions, changing the expected fuel consumption and travel times for barges and tugboats.

- **Wind:** Wind speed and strength may affect the maximum stackable height of containers allowed on vessels.

## SSS Potential in BC

The Fraser River is an obvious candidate for future SSS operations in BC, specifically along the lower Fraser area. A previous study in 2005 identified 18 potential sites for SSS terminals. These are distributed as follows:

*There are 18 potential SSS sites along the Fraser River*

*Table 4 Potential Intermodal Transfer Points Along the Fraser River*

| Lower Fraser and North Arm[6] | Lower Central Fraser River[7] | Upper Central Fraser River[8] | Upper Fraser River[9] |
|---|---|---|---|
| Eburne | Fraser Delta | Parsons Channel | Mission Foreshore |
| Mitchell Island | Burnaby Big Bend | Barnston Island | |
| Tilbury Island | | Port Kells area | |
| Tilbury Island- Seaspan | | Pitt Meadows | |
| Coast 2000 | | | |

*Source Data: Greater Vancouver Short Sea Container Shipping Study*

Several of these sites have been identified as sites with pre-established facilities that are configured with the basic requirements necessary for SSS and would require minimal investment to upgrade the site to be fully usable for SSS operations.

# Model Parameters

The model captures economic benefits as the cost differences in fuel expenditures, labour expenditures, and maintenance expenditures between the alternative option and the current transportation mode. Indirect benefits are also captured in the model as savings due to freed up port capacity.

[6] Approximately from Steveston to Alex Fraser Bridge
[7] Approximately from Alex Fraser Bridge to Port Mann Bridge
[8] Approximately from Port Mann Bridge to Maple Ridge area
[9] Approximately from Maple Ridge to Mission

Environmental benefits, expressed in terms of tonnes of pollutants saved, are determined as well.

## Route/Travel Distance

Benefits and costs calculations are based on freight transportation from Delta Port to Sumas. Although the Sumas location does not currently have an established container transfer terminal, this route was chosen for several reasons:

- A reasonable, feasible “long-haul” destination –one which offers significant benefits in terms of road travel congestion mitigation

- Sumas has the potential of becoming a multi-modal inland transfer terminal, as it would be in proximity to the Trans-Canada Highway and rail network, and also there is access to a rail link into the USA.

## Cost of Operations

The following expenditures were included as part of the cost of operations:

**Fuel expenditures**
To calculate fuel expenditures the following variables were measured:

- Round trip road distance (km) and river distance (km)
- Average round trip duration
- Fuel consumption per km (trucks) and hour (marine)
- Number of haulage trips per day, per year
- Fuel cost per liter

**Transport Labour expenditures**
Total labour costs were arrived at using the following inputs:

- Number of truck drivers and tug/barge personnel per day
- Mean base salary for truck drivers and tug crew for GVRD region, at the 75th percentile, plus 30% employee benefits

**Vehicle Maintenance expenditures**
The inputs for transport vehicle maintenance expenditures were:

- Number of km traveled per year and maintenance cost per km (truck)
- Number of tug/barge hours per year and maintenance cost per hour of vessel use.

**Inland Transfer Terminal Operation Costs**

The following assumptions were used in constructing Inland Transfer Terminal costs:

Truck Offloading

- Labour hours per container: 20 minutes
- Labour rate/hour: $50
- Equipment rate/container move: $30
- Overhead and profit charge: 50%

Tug/Barge Offloading

- Labour hours per container: 20 minutes
- Labour rate/hour: $50
- Equipment rate/container move: $50
- Overhead and profit charge: 50%

## Environmental Impact

Calculation of total pollutant emissions involved the following data:

- Truck and tug/barge operating hours per year
- Weighted average engine horsepower
- Liters of fuel consumed per year
- Kg. of CO2 produced per liter of fuel
- NOX emissions (grams/horsepower-hour)
- Particulate emissions (grams/horsepower-hour)

The Environmental Protection Agency's (EPAs) Emissions Standards 2007 were used in calculations to determine the quantity of pollutants produced as a result of this transport activity.

## Exclusions

- As this is a comparative analysis, on-board/on-truck container transfer costs at Delta Port were not included, as these costs apply, regardless of the mode of transport chosen.

- Costs incidental to direct transport operations, for example, land acquisition, municipal services, and taxes were not considered.

- Public policy issues and stakeholder considerations were not elaborated upon in this report.

# Economic & Environmental Impact - Trucking

This analysis examines the transport and handling costs, and emission of pollutants, under different fuel cost and average truck speed assumptions.

Two hundred (200) TEUs per day (100 40 ft. containers) are assumed to be transported between Delta Port and Sumas, with an *empty backhaul*. This volume of freight is handled daily, 360 days per year. The equipment used is a conventional 5-axle semi-truck trailer. Inland terminal handling costs were incorporated as well into the calculations.

*Table 5 Economic and Environmental Impact for Trucking*

***Optimistic Scenario:***
***Cost/TEU = $210***
***Emission = 5,705 tons***

***Versus***

***Pessimistic Scenario:***
***Cost/TEU = $252***
***Emission = 9,984 tons***

| | Optimistic Scenario | | | Pessimistic Scenario |
|---|---|---|---|---|
| **Average Trip Speed (km/hr)** | **70** | **60** | **50** | **40** |
| **Fuel Price ($/l)** | **$1.20** | **$1.30** | **$1.40** | **$1.50** |
| | | | | |
| **Economic Impact** | | | | |
| Annual Fuel Consumption (l) | 2,129,100 | 2,484,000 | 2,980,800 | 3,726,000 |
| Total Fuel Expenditure ($) | $2,555,000 | $3,229,200 | $4,173,100 | $5,589,000 |
| Total Fuel, Labour & Mtce Costs/Yr | $12,217,400 | $12,891,600 | $13,835,500 | $15,251,400 |
| Total Transport & Handling Cost | $15,091,000 | $15,765,000 | $16,709,000 | $18,125,000 |
| Cost/TEU ($$) | $210 | $219 | $232 | $252 |
| | | | | |
| **Environmental Impact** | | | | |
| Total Emissions - All Types-/Yr (tons) | 5,705 | 6,656 | 7,987 | 9,984 |

An *Optimistic* and a *Pessimistic* scenario was constructed, with the Optimistic Scenario achieving an average truck speed on the route of 70 km/hour, with a fuel price of $1.20 per liter. The Pessimistic Scenario had an average truck speed of 40 km/hour, and a $1.50 per liter fuel price. Two intermediate scenarios – 50/$1.40, and 60/$1.30 – were also produced.

This analysis confirmed several expectations, namely:

***Roadway congestion increases truck operating cost and emissions of pollutants***

1. The cost per TEU increases with both an increase in fuel price and with a decrease in average truck speed due to roadway congestion. These two factors negatively impact the cost/TEU by 20 percent.

2. Air pollution increases significantly with longer haul-time, attributable to traffic congestion. In fact, a 75 percent increase in total emissions is associated with a decrease in average truck time from 70 km/hour to 40 km/hour.

## Long-Combination Truck Use

Significant economic and environmental benefits are realizable with the use of long-combination vehicles. LCV configured trucks are capable of hauling two 40 ft. containers in tandem on two trailers, with the power provided by a single engine.

LCVs are a recent innovation to BC roads, however their use is proliferating as their benefits are beginning to be fully understood. The table below illustrates the value of deploying long-combination trucks to transport freight containers on this designated route

*Table 6 Economic and Environmental Impact for LCV*

| | Semi-Trailer | LCV | Savings |
|---|---|---|---|
| | | | |
| **Economic Impact** | | | |
| Annual Fuel Consumption (l) | 2,462,000 | 1,231,200 | 1,230,800 |
| Total Fuel Expenditure ($) | $2,954,900 | $1,477,400 | 1,477,500 |
| Total Fuel Labour& Mtce Costs/Yr | $12,617,300 | $6,308,600 | 6,308,700 |
| Total Transport & Handling Cost | $15,491,000 | $9,182,000 | 6,309,000 |
| Cost/TEU ($$) | $215 | $128 | $88 |

| | | | |
|---|---|---|---|
| **Environmental Impact** | | | |
| Total Emissions - All Types-/Yr (tons) | 6,598 | 3,298 | 3,300 |

The following conclusions were derived:

***40% cost savings and 50% emission reduction realized with LCV***

1. A saving of $88/TEU (which equates to 40%) is realized with LCV use over conventional semi-truck use.

2. Emissions are reduced by 3,300 tons per year (50%).

## Truck Traffic Road Impact

The method for determining the pavement “wear-and-tear” attributable to vehicle traffic requires some explanation. Engineers have developed a measure – “Equivalent Single Axle Loading” or “ESAL”- to estimate the impact that vehicles have on the roadway surface.

One ESAL is known to cause a quantifiable and standardized amount of damage to the pavement structure equivalent to one pass of a single, 18,000 pound, dual-tire axle with tires inflated to 110 psi.

Numerous factors go into the calculation of a vehicle's ESAL impact, including the number of axles, the weight distribution, vehicle speed, and tire pressure. A vehicle's ESAL value is multiplied by the number of kilometers driven, to obtain an ESAL-km value.

For purposes of this study, the ESAL calculation method employed by the BC Ministry of Highways was used. The ESAL-km values associated with a round-trip from Delta Port to Sumas were computed for two types of vehicles – conventional 5-axle semi-trailer trucks, and 8-axle long-combination-vehicle trucks.

Details pertaining to the ESAL calculation methodology may be found in the Appendix.

## Road Use ESAL Impact - Delta Port to Sumas

**Assumptions:**
50,000 GVW trucks are used to transport containers
Actual Axle Group loads are Max. Gross Vehicle Weights, reduced by 28 pct. "across the board". These figures take into account the actual vehicle loads -Containers (3,600kg), and Container Payloads (11,400kg) - which are 28% less than the Max. GVWs.

| | Semi | LCV | Savings |
|---|---|---|---|
| | 5 Axle | 8 Axle | |
| Round Trip Length (km) | 184 | 184 | |
| Nbr. Round Trips/Day | 100 | 50 | 50 |
| Nbr. Days/Year | 360 | 360 | |
| Nbr. Round Trips/Year | 36,000 | 18,000 | 18,000 |
| **Total km/Year** | **6,624,000** | **3,312,000** | **3,312,000** |

*LCV can haul two 40 ft containers therefore reducing the number of round trips by half*

| Vehicle Configuration | Assumed Percent Loaded | Vehicle-Km Travelled/Yr | ESALs per Single Vehicle Pass | ESAL-km |
|---|---|---|---|---|
| Semi Trailers (Current) | 100% | 6,624,000 | 2.034 | 13,473,216 |
| LCV (Rocky Mountain Double) | 72% | 3,312,000 | 3.007 | 9,959,184 |
| | | | | |
| **Road Use Reduction due LCV Use** | | | | **3,514,032** |
| **Percentage Reduction** | | | | **26%** |
| | | | | |
| **Road Use Reduction due SSS Use** | | | | **13,473,216** |
| **Percentage Reduction** | | | | **100%** |

**Note:**
LCV refers to "Long Combination Vehicle"
LCV Assumed Pct Loaded reflects container mix (e.g. 40 ft, 20 ft. etc.) on LCVs

This analysis arrived at the following conclusions:

1. Conventional truck use on the Delta Port to Sumas route results in 13.5 million ESAL-km of roadway wear-and-tear.

*26% road use reduction with LCV and 100% road use reduction with barge*

2. The ESAL-km impact with long-combination-vehicle use on this route has is 10 million ESAL-km, a 26 percent saving.

3. 13.5 million ESAL-km (100%) are saved if containers are transported by tug/barge on the Fraser River rather than by roadway.

## Economic & Environmental Impact - Barging

This analysis examines the transport and handling costs, and emission of pollutants, under different fuel cost and average barge/tug speed assumptions.

*Average trip speeds are affected by tidal and freshet conditions*

Two hundred (200) TEUs per day (360 days a year) are assumed to be transported between Delta Port and Sumas, with an *empty backhaul*. The equipment used is can be either a tug/barge combination, or a motorized barge (the prevalent transport mode on the Rhine River). Inland terminal handling costs were incorporated as well into the calculations.

*Table 7 Economic and Environmental Impact for Barging (200 TEUs)*

***Optimistic Scenario:***
***Cost/TEU = $127***
***Emission = 2,075 tons***

***Versus***

***Pessimistic Scenario:***
***Cost/TEU = $130***
***Emission = 2,982 tons***

| | Optimistic Scenario | | | | Pessimistic Scenario |
|---|---|---|---|---|---|
| **Average Trip Speed (knots)** | **6.5** | **5.9** | **5.4** | **4.9** | **4.3** |
| **Fuel Price ($/l)** | **$1.20** | **$1.25** | **$1.30** | **$1.40** | **$1.50** |
| | | | | | |
| **Economic Impact** | | | | | |
| Annual Fuel Consumption (l) | 775,200 | 836,800 | 910,700 | 1,001,000 | 1,113,800 |
| Total Fuel Expenditure ($) | $930,240 | $1,046,000 | $1,183,900 | $1,401,300 | $1,670,800 |
| Total Fuel, Labour & Mtce Costs/Yr | $1,405,740 | $1,528,300 | $1,674,300 | $1,901,700 | $2,183,600 |
| Total Transport & Handling Cost | $9,131,000 | $9,253,000 | $9,399,000 | $9,627,000 | $9,909,000 |
| Cost/TEU ($$) | $127 | $129 | $131 | $134 | $138 |
| | | | | | |
| **Environmental Impact** | | | | | |
| Total Emissions - All Types-/Yr (tons | 2,075 | 2,240 | 2,438 | 2,680 | 2,982 |

This analysis confirmed several expectations, namely:

1. The cost per TEU increases with both an increase in fuel price and with a decrease in average tug/barge speed, likely attributable to tidal and freshet conditions. These two factors negatively impact the cost/TEU by approximately 10 percent.

2. Air pollution increases significantly with longer haul-time. In fact, a 44 percent increase in total emissions is associated with a decrease in average transit time from 6.5 knots (12 km/hour) to 4.3 knots (8 km/hour).

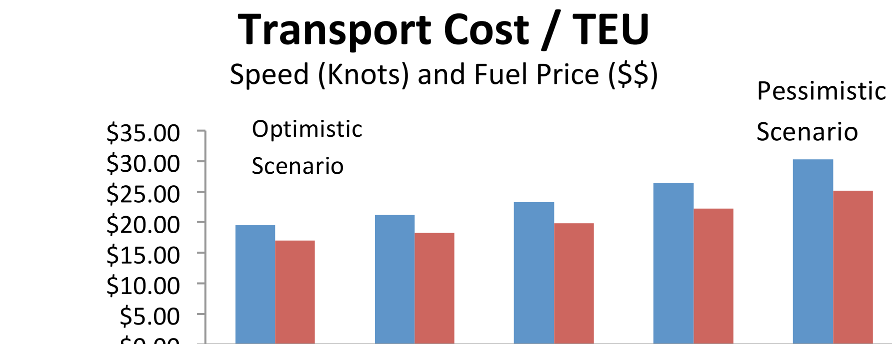
## Comparison: 200 TEU vs. 400 TEU Barges

Given that 400 TEU barges are currently also in operation, it was deemed advisable to examine the economics and environmental impacts associated with these two types of crafts.

The costs presented in the graph below are inclusive of fuel, labour and maintenance expenses associated with container transport over the designated route. **Inland terminal handling costs have not been included!**

*At higher TEUs transport costs are lower in every scenario*




| | 6.5K/$1.20 | 5.9K/$1.25 | 5.4K/$1.30 | 4.9K/$13.0 | 4.3K/$1.50 |
|---|---|---|---|---|---|
| 200 TEU Barge | $19.52 | $21.23 | $23.25 | $26.41 | $30.33 |
| 400 TEU Barge | $17.01 | $18.30 | $19.84 | $22.25 | $25.22 |

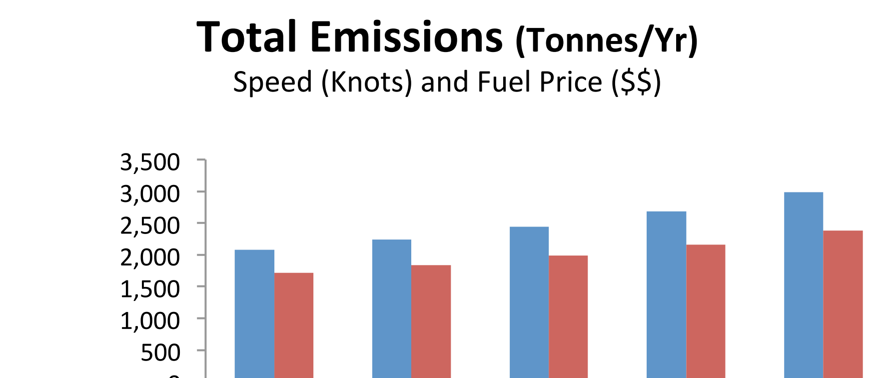
*Figure 1 Transport Cost/TEU Comparison for Barge*

Note:

- The dollar amounts indicated refer to the direct operating cost (fuel, labour & maintenance) associated with container transport by barge/tug. The values indicate the transport cost per TEU.
- "6.5K/$1.20" refers to an average transit speed of 6.5 knots, and a fuel price of $1.20 per liter. Etc.
- "200 TEU Barge" refers to a tug/barge that is capable of carrying 200 TEUs (100 40 ft. containers) in a single transit.

The graph, which follows, estimates the total emissions (CO2, NOx, NMHC) in tonnes per year associated with the operation of 200 and 400 TEU tugs/barges.

*At higher TEUs total emissions are lower in every scenario*




| | 6.5K/$1.20 | 5.9K/$1.25 | 5.4K/$1.30 | 4.9K/$13.0 | 4.3K/$1.50 |
|---|---|---|---|---|---|
| 200 TEU Barge | 2,075 | 2,240 | 2,438 | 2,680 | 2,982 |
| 400 TEU Barge | 1,719 | 1,840 | 1,985 | 2,163 | 2,385 |

*Figure 2 Total Emission Comparison for Barge*

**Conclusions:**

*400 TEU barge operations have minimum cost differences of 13% less vs. 200 TEU barge operations*

1. 400 TEU tugs/barges are more efficient than 200 TEU craft. Direct operating costs, on a Cost/TEU basis, are lower in the range of 13% to 17%.

2. Pessimistic scenario Transport Costs/ TEU is approximately 50% higher than the Optimistic scenario costs.

3. Again, as is the case with Transport Cost/TEU 400 TEU tugs/barges are more efficient in terms of pollutant emission than their 200 TEU counterpart. Emissions are approximately 20% less with 400 TEU than with 200 TEU craft.

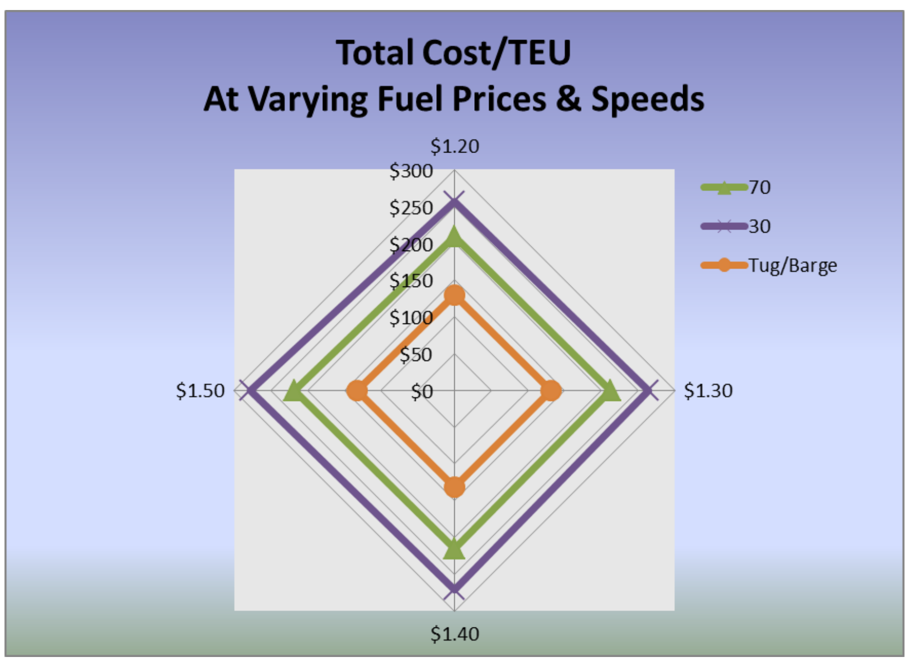
*400 TEU barge operations produce 20% less emission*

4. Transit speed changes can increase emissions by as much as 40 percent, regardless of which type of equipment is used (200 TEU or 400 TEU).

## Comparison: Conventional Trucking vs. Barging

Ultimately, the question to be addressed is whether barging is economically advantageous to trucking. The graph below captures clearly shows that container transport by tug/barge is, from an economic standpoint preferable to trucking. **Regardless of fuel cost, or average truck road traffic speed, movement of containers by barge is less costly.**

*Tug/barge in every scenario is more economically advantageous than trucking*



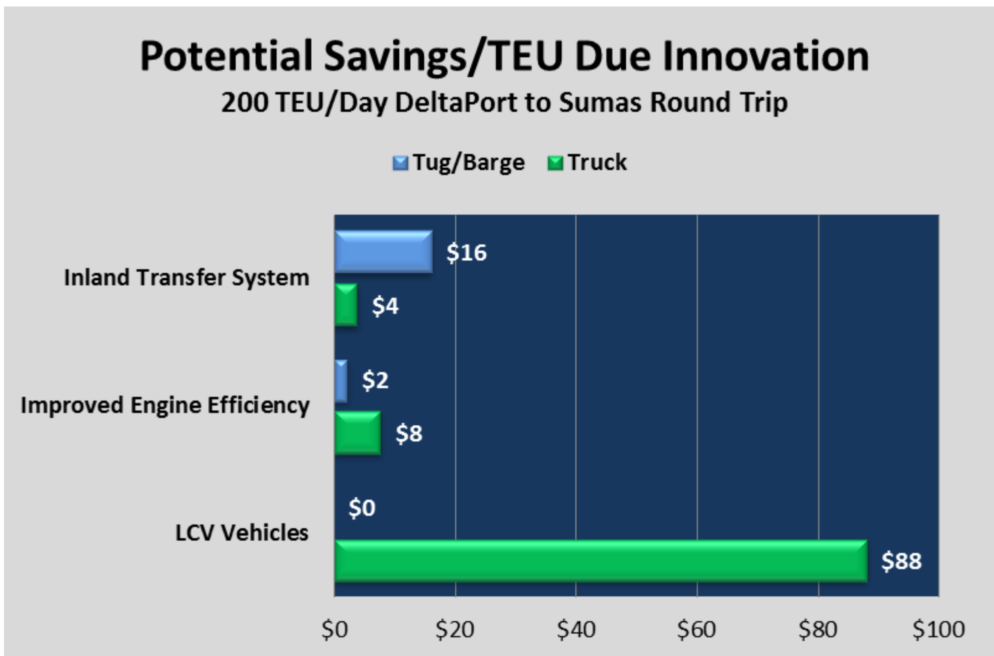
*At a transit speed of 60 km/hour LCV transport and Barge have equivalent costs*

It is important to note, however, that in **terms of Total Cost/TEU, Tug/Barge and LCV transport are equivalent regardless of the price of fuel, but assuming a transit speed of 60 km/hour.**

The comparability in cost is explained by the fact that, while transport costs with the marine option are lower than with the LCV truck option, inland terminal transfer costs are higher.

## Potential Savings Due To Innovations

*Automation of terminals can generate SSS related savings*




A cursory examination of available literature, and discussion with several industry people, indicated several potential savings may be attributable to innovations within the trucking and marine industries. These are:

1. The deployment of long-combination vehicles rather than 5-axle semi-trailer
2. Partial automation of the inland transfer system
3. Improvements in truck and marine engine efficiencies

**Long-Combination Vehicle Use** This is a well-developed technology which has already been widely deployed within BC, and which has been discussed in an earlier section of this report.

**Automation** Utilization of newer terminal equipment, such as reach stackers, ship-to-crane spreaders, sidelifters, and automated "container warehouses". The latter offers the added benefit of a reduced storage acreage requirement and rapid container retrieval.

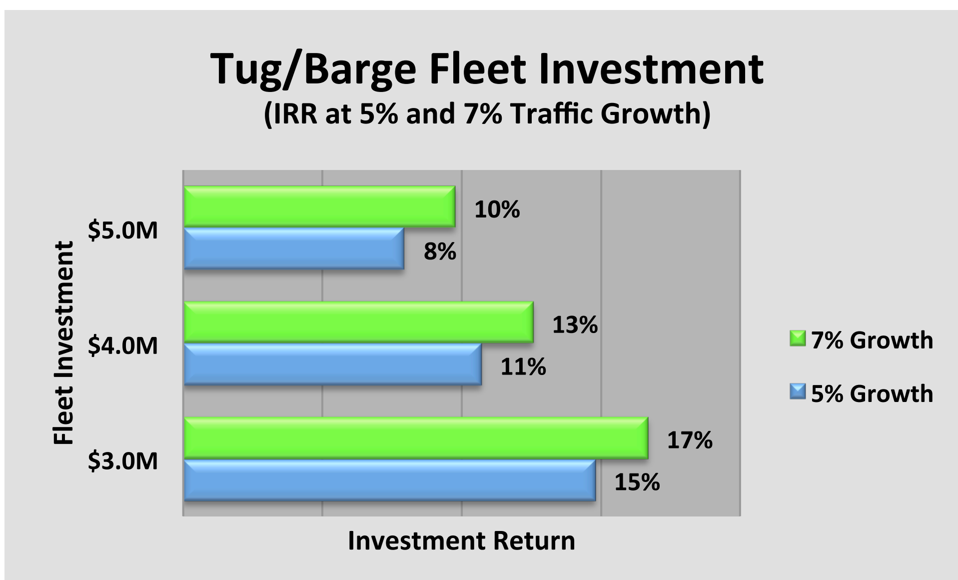
A conservative efficiency improvement figure of 10% for truck off/on load, and 15% for barge off/on load was used in this report.

**Engine Efficiency** Upgrading of truck and marine diesel engines to take advantage of fuel consumption related engine performance. A conservative 10% efficiency improvement figure was used in this study.

## Tug/Barge Fleet Investment

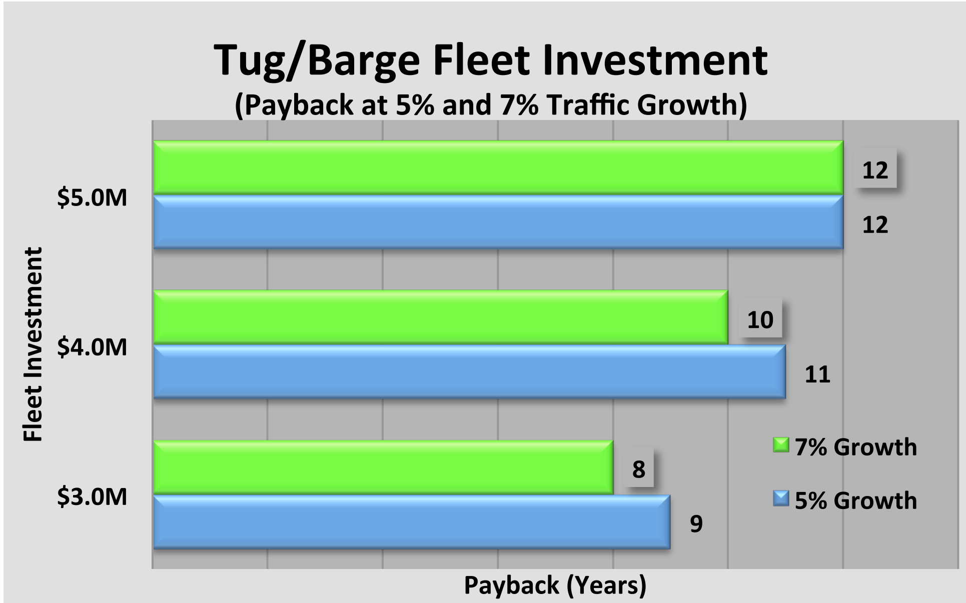
The internal rate of return and payback was calculated for tug/barge investments valued at $3, $4 and $5 million. Transport costs of $25 per TEU, debt retirement at 20% of transport costs, and a first year volume of 72,000 TEUs was incorporated into the model. Two assumed annual growth in volume rates were used: 5% and 7%.

*IRR is expected to range from 8% to 15%*



*Payback period is expected to range from 8 to 12 years*



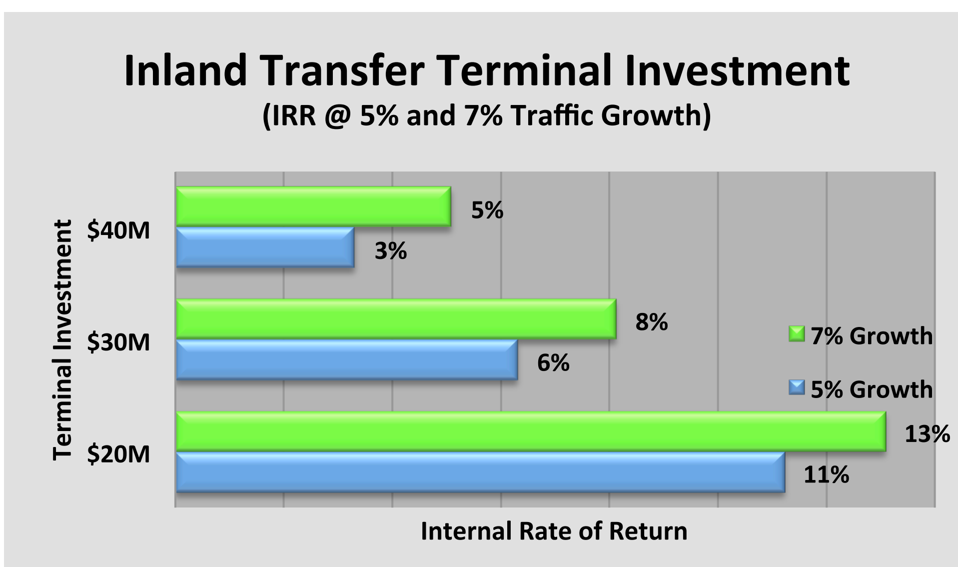

Depending upon the size of the investment in fleet and traffic growth, the internal rate of return varies from 8%to 15%. Payback varies from 8 years to 12 years.

## Inland Transfer Terminal Investment

The internal rate of return and payback was calculated for inland transfer terminal investments valued at $20, $30 and $40 million.

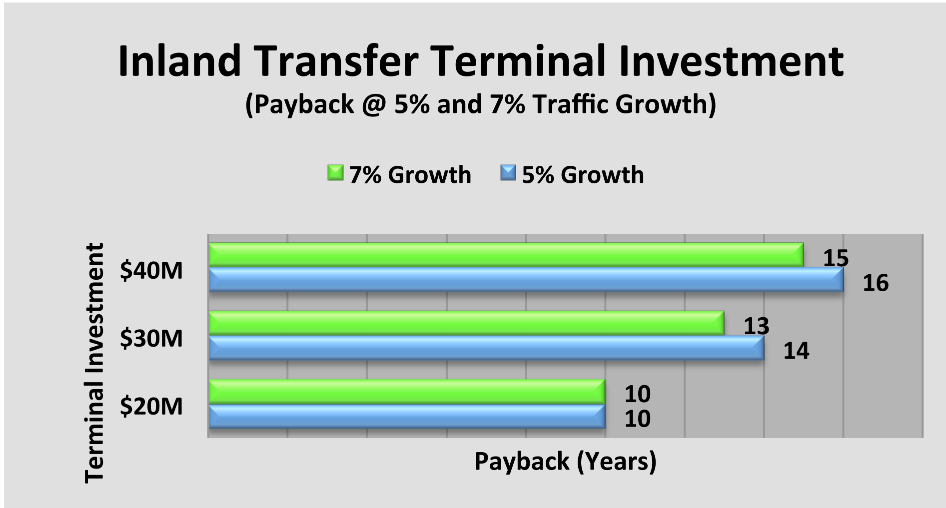
Operating/transfer costs of $130 per TEU, debt retirement at 20% of operating/transfer costs, and a first year volume of 72,000 TEUs was incorporated into the model. Two assumed annual volume growth rates were used: 5% and 7%.

*IRR is expected to range from 3% to 13%*



*Payback period is expected to range from 10 to 15 years*




Depending upon the size of the investment in fleet and traffic growth, the internal rate of return varies from 3%to 13%. Payback varies from 10 to 16 years.

# Summary and Conclusions

This study was undertaken in order to obtain a deeper understanding of the relative merits of two modes of containerized freight transport, trucking and short-sea-shipping on a specific Lower Mainland route – Delta Port to Sumas.

Whereas knowledgeable industry readers of this report may question certain cost figure inputs into the model, it needs to be borne in mind that much of this work was based on publicly available statistical information, some of which may be incomplete or out-of-date. Nevertheless, the authors of this report believe that the conclusions that can be drawn from this work remain valid.

## Major Findings

1. For a 184km round-trip route distance, transport of freight containers by tug/barge is less expensive than with transport by semi-trailer truck.

2. As trip duration time increases due to traffic congestion on the roadway network, trucking becomes increasingly less competitive to short-sea-shipping.

3. Economies of scale, and thus reduced transport cost/TEU, are achieved with higher capacity tug/barge equipment.

4. In terms of cost, transport by long-combination vehicle (LCV) trucks is comparable to short-sea-shipping. This is because lower marine transport costs are offset by inland terminal transfer costs.

5. Marine transport is far more "environmentally friendly" than truck transport, as a far lower tonnage of pollutant emissions are generated.

6. Road transport of freight containers involves substantial public costs in terms of degradation of roadway pavement. Whereas the use of LCV trucks results in a 26 percent ESAL-km (a measure of roadway wear-and-tear) reduction, the short-sea-shipping option achieves a 100 percent reduction over the use of conventional semi-trailer trucks.

7. Depending upon the dollar value of fleet and inland terminal investments required, and anticipated growth in container traffic volumes, such investments offer an internal rate of return of between 3% and 13%, and a payback of between 8 and 15 years.

8. Efficiency gains are possible through fleet modernization (reduced fuel consumption) and inland transfer terminal automation.

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# Appendeces

 

# Appendix 1: Economic & Environmental Impact Worksheet – Trucks

## Economic & Environmental Impact Analysis

**Note: Assumes Movement of 200 TEUs/Day, Empty Backhaul, With 5-Axle Truck, With Fuel Price Changes**

| | Optimistic Scenario | | | Pessimistic Scenario |
|---|---|---|---|---|
| **Average Trip Speed (km/hr)** | **70** | **60** | **50** | **40** |
| **TEU's per Day** | 200 | 200 | 200 | 200 |
| Two-Way Trip Length (km) | 184 | 184 | 184 | 184 |
| | | | | |
| Nbr. Trips/Day | 100 | 100 | 100 | 100 |
| Nbr. Days/Year | 360 | 360 | 360 | 360 |
| Nbr. Trips/Year | 36,000 | 36,000 | 36,000 | 36,000 |
| **Total km/Year** | **6,624,000** | **6,624,000** | **6,624,000** | **6,624,000** |
| | | | | |
| **Economic Impact** | | | | |
| Avg. Trip Duration (hrs) | 3.3 | 3.8 | 4.6 | 5.8 |
| Fuel consumption/truck/hour (l) | 18.0 | 18.0 | 18.0 | 18.0 |
| Nbr. Truck Operating Hours/Yr | 118,286 | 138,000 | 165,600 | 207,000 |
| **Annual Fuel Consumption (l)** | **2,129,143** | **2,484,000** | **2,980,800** | **3,726,000** |
| Fuel Cost ($/l) | $1.20 | $1.30 | $1.40 | $1.50 |
| **Total Fuel Expenditure ($/Yr)** | **$2,554,971** | **$3,229,200** | **$4,173,120** | **$5,589,000** |
| | | | | |
| Nbr. Drivers /Day | 100 | 100 | 100 | 100 |
| Annual Base Salary + 30% Benefits/Driver | $90,000 | $90,000 | $90,000 | $90,000 |
| **Total Labour Expenditure** | **$9,000,000** | **$9,000,000** | **$9,000,000** | **$9,000,000** |
| | | | | |
| Vehicle Maintenance Cost/km | $0.10 | $0.10 | $0.10 | $0.10 |
| **Total Maintenance Expenditure ($)** | **$662,400** | **$662,400** | **$662,400** | **$662,400** |
| | | | | |
| **Total Fuel, Labour & Mtce Costs/Yr** | **$12,217,371** | **$12,891,600** | **$13,835,520** | **$15,251,400** |
| **Total Fuel, Labour & Mtce Costs/Hr** | **$103** | **$93** | **$84** | **$74** |
| **Total Fuel, Labour & Mtce Costs/TEU** | **$170** | **$179** | **$192** | **$212** |
| | | | | |
| Deep Sea Terminal Loading Cost/YR | | | | |
| Inland Terminal Transfer Cost | $2,873,700 | $2,873,700 | $2,873,700 | $2,873,700 |
| **Total Transport & Handling Cost** | **$15,091,000** | **$15,765,000** | **$16,709,000** | **$18,125,000** |
| **Total Cost/TEU ($$)** | **$210** | **$219** | **$232** | **$252** |
| | | | | |
| **Route-Specific Environmental Impact** | | | | |
| CO2 Produced / Liter (kg) | 2.67 | 2.67 | 2.67 | 2.67 |
| **Total CO2 Emissions/Yr (tons)** | **5,685** | **6,632** | **7,959** | **9,948** |
| Average Trip Times (Hrs) | 3.3 | 3.8 | 4.6 | 5.8 |
| Nbr. Truck Operating Hours/Year | 118,286 | 138,000 | 165,600 | 207,000 |
| Weighted Average Fleet Horsepower | 493 | 493 | 493 | 493 |
| NOX Emissions (g/hp-hr) | 0.20 | 0.20 | 0.20 | 0.20 |
| **Total NOx Emissions /Yr (tons)** | **11.66** | **13.61** | **16.33** | **20.41** |
| NMHCO Emissions (g/hp-hr) | 0.14 | 0.14 | 0.14 | 0.14 |
| **Total NMHCO Emissions/Yr (tons)** | **8.16** | **9.52** | **11.43** | **14.29** |
| PM Emissions (g/hp-hr) | 0.01 | 0.01 | 0.01 | 0.01 |
| **Total Particulate Matter Emissions/Yr (tons)** | **0.58** | **0.68** | **0.82** | **1.02** |
| **Total Emissions - All Types-/Yr (tons)** | **5,705** | **6,656** | **7,987** | **9,984** |

 

# Appendix 2: Economic & Environmental Impact Worksheet – Tug/Barge

## Economic & Environmental Impact Analysis

**Note: Assumes Movement of 200 TEUs/Day, Empty Backhaul, With Fuel Price & Trip Speed Changes**

| | | | | | |
|---|---|---|---|---|---|
| Conversion knots to km/hr | 1.852 | | | | |
| | **Optimistic Scenario** | | | | **Pessimistic Scenario** |
| **Average Trip Speed (km/hr)** | **12** | **11** | **10** | **9** | **8** |
| **Average Trip Speed (knots)** | **6.5** | **5.9** | **5.4** | **4.9** | **4.3** |
| **TEUs Per Trip (Day)** | **200** | **200** | **200** | **200** | **200** |
| Two-Way Trip Length (km) | 166 | 166 | 166 | 166 | 166 |
| | | | | | |
| Nbr. Trips/Day | 1 | 1 | 1 | 1 | 1 |
| Nbr. Days/Year | 360 | 360 | 360 | 360 | 360 |
| Nbr. Trips/Year | 360 | 360 | 360 | 360 | 360 |
| **Total km/Year** | **59,760** | **59,760** | **59,760** | **59,760** | **59,760** |
| **Total TEU's/Year** | **72,000** | **72,000** | **72,000** | **72,000** | **72,000** |
| | | | | | |
| **Economic Impact** | | | | | |
| Avg. Round Trip Duration (hrs) | 15.8 | 17.1 | 18.6 | 20.4 | 22.8 |
| Fuel consumption/tug/hour (l) | 136 | 136 | 136 | 136 | 136 |
| Nbr. Tug/Barge Operating Hours/Yr | 5,700 | 6,153 | 6,696 | 7,360 | 8,190 |
| **Annual Fuel Consumption (l)** | **775,200** | **836,771** | **910,656** | **1,000,960** | **1,113,840** |
| Fuel Cost ($/l) | $1.20 | $1.25 | $1.30 | $1.40 | $1.50 |
| **Total Fuel Expenditure ($/Yr)** | **$930,240** | **$1,045,964** | **$1,183,853** | **$1,401,344** | **$1,670,760** |
| | | | | | |
| Nbr. Personnel/Trip | 3 | 3 | 3 | 3 | 3 |
| Annual Base Salary + 30% Benefits | $130,000 | $130,000 | $130,000 | $130,000 | $130,000 |
| **Total Labour Expenditure** | **$390,000** | **$390,000** | **$390,000** | **$390,000** | **$390,000** |
| | | | | | |
| Tug/Barge Maintenance Cost/hour | $15.00 | $15.00 | $15.00 | $15.00 | $15.00 |
| **Total Maintenance Expenditure ($)** | **$85,500** | **$92,291** | **$100,440** | **$110,400** | **$122,850** |
| | | | | | |
| **Total Fuel, Labour & Mtce Costs/Yr** | **$1,405,740** | **$1,528,255** | **$1,674,293** | **$1,901,744** | **$2,183,610** |
| **Total Fuel, Labour & Mtce Costs/Hr** | **$247** | **$248** | **$250** | **$258** | **$267** |
| **Cost/TEU ($$)** | **$19.52** | **$21.23** | **$23.25** | **$26.41** | **$30.33** |
| | | | | | |
| Deep Sea Terminal Loading Cost/YR | | | | | |
| Inland Terminal Transfer Cost | $7,725,000 | $7,725,000 | $7,725,000 | $7,725,000 | $7,725,000 |
| **Total Transport &Handling Cost** | **$9,131,000** | **$9,253,000** | **$9,399,000** | **$9,627,000** | **$9,909,000** |
| **Total Cost/TEU** | **$127** | **$129** | **$131** | **$134** | **$138** |
| | | | | | |
| **Route-Specific Environmental Impact** | | | | | |
| CO2 Produced / Liter (kg) | 2.67 | 2.67 | 2.67 | 2.67 | 2.67 |
| **Total CO2 Emissions/Yr (tons)** | **2,070** | **2,234** | **2,431** | **2,673** | **2,974** |
| Average Trip Times (Hrs) | 15.8 | 17.1 | 18.6 | 20.4 | 22.8 |
| Nbr. Tug/Barge Operating Hours/Year | 5,700 | 6,153 | 6,696 | 7,360 | 8,190 |
| Weighted Average Fleet Horsepower | 2,700 | 2,700 | 2,700 | 2,700 | 2,700 |
| NOX Emissions (g/hp-hr) | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| **Total NOx Emissions /Yr (tons)** | **3.08** | **3.32** | **3.62** | **3.97** | **4.42** |
| NMHCO Emissions (g/hp-hr) | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 |
| **Total NMHCO Emissions/Yr (tons)** | **2.15** | **2.33** | **2.53** | **2.78** | **3.10** |
| PM Emissions (g/hp-hr) | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| **Total Particulate Matter Emissions/Yr (tons)** | **0.15** | **0.17** | **0.18** | **0.20** | **0.22** |
| **Total Emissions - All Types-/Yr (tons)** | **2,075** | **2,240** | **2,438** | **2,680** | **2,982** |

 

# Appendix 3: Road Use Impact Calculation Worksheet

*Conventional (Semi) Configuration vs Long Combination Vehicle (LCV)Configuration*

**ESAL Definition:** Equivalent Single Axle Loadings (measure of highway wear & tear)

**ESAL Calc:** (Total Freight/Payload Capacity)* Truck ESAL*2

**Source:**

Calculations utilize formula contained in Ministry of Transport BC, Geotechnical, Materials & Pavement Engineering, "Pavement Structural Design Guidelines, Technical Circular T-01/04", P.14.

Gross Volume Weights, and Planned (Actual) Operating Weights, as provided by Truck/Trailer Manufacturer

| Axle Group LCV Configuration | Multiplier | Axle Group Load (kg x 1000) Max. GVW | Actual | Exponent | ESALs Per Vehicle Pass GVW | Actual |
|---|---|---|---|---|---|---|
| Steering Axle | 0.004836 | 5.5 | 4.0 | 2.9093 | **0.689** | **0.265** |
| Drive Tandem (Tractor) | 0.001515 | 17.0 | 12.2 | 2.543 | **2.039** | **0.884** |
| Tridem (Trailer 1) | 0.002363 | 24.0 | 17.3 | 2.113 | **1.949** | **0.974** |
| Tandem (Trailer 2) | 0.001515 | 17.0 | 12.2 | 2.543 | **2.039** | **0.884** |
| | | | | **Total** | **6.717** | **3.007** |
| | | | | | **100%** | **45%** |

| Axle Group Conventional Semi Configuration | Multiplier | Axle Group Load (kg x 1000) Max. GVW | Actual | Exponent | ESALs Per Vehicle Pass GVW | Actual |
|---|---|---|---|---|---|---|
| Steering Axle | 0.004836 | 5.5 | 4.0 | 2.9093 | **0.689** | **0.265** |
| Drive Tandem (Tractor) | 0.001515 | 17.0 | 12.2 | 2.543 | **2.039** | **0.884** |
| Tandem (Rear) | 0.001515 | 17.0 | 12.2 | 2.543 | **2.039** | **0.884** |
| | | | | **Total** | **4.768** | **2.034** |
| | | | | | **100%** | **43%** |

 