COST ANALYSIS OF WEYERHAEUSER'S PEMBINA TIMBERLANDS LOG HAUL

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ABSTRACT

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Keywords; log truck configurations, Forest Management Area [FMA], contractors, 10 axle B-train, 9 axle B-train, 8 axle B-train, 8 axle quad, 8 axle jeep-tridem and the 7 axle tri-tri, cost effective, operational cost, potential savings.

This thesis compares the log truck configurations currently used to haul roundwood on the Pembina Forest Management Area located in west central Alberta. Weyerhaeuser is the licensee and employs six stump to dump contractors currently operating a fleet of 90 trucks. After processing occurs at landings 8 foot to 20 foot logs are delivered to its Edson and Drayton Valley mills using a multitude of truck configurations that have been stratified into the following 6 configuration groups. These are the 10 axle B-train, 9 axle B-train, 8 axle B-train, 8 axle quad, 8 axle jeep-tridem and the 7 axle tri-tri. These configurations have varying payload, purchase price, parts and repairs, fuel consumption and additional costs such as tires. This study determined the most cost-effective truck configuration to be the 10 axle King B which had an hourly operating cost of $151.45/hour and the lowest operational cost per tonne/hour of $2.79 hauling softwood to Drayton Valley and $2.98 hauling hardwood to Edson. A potential savings of $3,950,669 annually was determined if the implementation of the most cost effective trucking fleet was accomplished. Further insight is provided into potential barriers and room for improvement within the Pembina log haul.

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1. INTRODUCTION

Maintaining wood flow to the mill yard is critical in maintaining an efficient wood product supply chain. However, long distance transportation of timber comprises a large portion of the total cost in logging operations; anywhere from 40-60% of all costs associated with harvesting (Norstebo and Johansen 2012). Timber transport from roadside to processing facilities can be done by waterway, railway or roadway (Uusitalo and Pearson 2010). Trucks are a crucial tool used for delivering wood to mill yards across the world because they are both flexible and quick, meaning wood can arrive from various locations rapidly allowing managers to adapt to adverse weather conditions or respond to mill desires. Structure and functionality of logging trucks are determined by timber harvesting method and needs of the mill (Norstebo and Johansen 2012). Whether hauling full-trees, tree-lengths or cut-to-length raw forest products, semi-trailer configurations are often used, and are subject to provincial standards.

This study will examine current methods of timber transportation used by contractors on the Pembina Forest Management Area (FMA), situated in west central Alberta. Within the Pembina FMA, Weyerhaeuser has a mill located in Edson, which produces oriented strand board. The product is made by stranding deciduous roundwood, the majority of which is comprised of *Populous tremuloides* Michx. and *Populous balsamifera* L. A second Weyerhaeuser mill is located in Drayton Valley; a sawmill that processes coniferous roundwood, mainly *Pinus contorta* Dougl. Ex Loud and *Picea glauca* (Moench) Voss. All transport to both mills is done by tractor-trailer.

Different truck configurations will be examined along with their associated costs and volume of timber delivered to the mill yard. The results of this study will determine the return on investment for each hauling configuration currently used in an effort to help improve profitability for contractors at current roundwood haul rates. Currently, Weyerhaeuser Pembina employs several contractors to harvest and deliver wood from stump to mill yard. The contractors use a variety of log trucks sourced from several provinces including British-Columbia and Saskatchewan. This multitude of configurations has been grouped into 6 categories, the 10 axle King B is the largest, followed by the 9 axle B-train, 8 axle B-train, 8 axle quad, 8 axle jeep-tridem and lastly the 7 axle tri-tri. Each additional axle provides larger payload but suffers at the expense of additional purchase price, fuel consumption, tires, maintenance, and a larger truck with more horsepower to pull the heavier load. In addition, government restrictions must balance the capacity and capabilities of highway infrastructure with the demands of industry. These payload limitations set in accordance with the ability of said configurations to distribute the gross-vehicle-weight [GVW] whilst not damaging infrastructure during that time of year.

1.1 OBJECTIVE

Weyerhaeuser currently bases its haul rates on the 8 axle truck configurations, however, over the past 3 years contractors have been adding more 9 and 10 axle B-trains to their fleets. In the 2017-2018 timber year the portion of volume hauled was as follows: 10 axle b-train 24.5%, 9 axle b-train 23.0%, 8 axle b-train 21.3%, 8 axle quad 16.9%, 7 axle tri-tri 9.8%, 8 axle jeep tridem 4.5%. Today 47.5% of volume is hauled on 9 and 10 axle trucks. This means there are substantial financial benefits to be shared between

Weyerhaeuser and the contractors. The objective of this thesis is to determine the most cost effective log truck configuration for Weyerhaeuser to use when moving logs to its Edson and Drayton Valley mills. This thesis will outline the operating cost per scheduled machine hour and per tonne/hour for each of the six configurations. In addition, this thesis will provide the potential cost savings for Weyerhaeuser when hauling with the most cost effective trucking fleet.

1.2. LITERATURE REVIEW

1.2.1 Methods of Long Distance Transport

Transport of roundwood from roadside to processing facilities can be done via waterway, railway or roadway (Norstebo and Johansen 2012). However railway and waterway transport are often times only appropriate over long distances (Norstebo and Johansen 2012). They also require initial transport by truck from roadside to port or loading terminal. Long distance transportation of timber comprises a large portion of the total cost in logging operations, anywhere from 40-60% of all costs associated with harvesting (Norstebo and Johansen 2012). Method of transport is determined by harvesting operations, geographic location, distance between roadside and mill yard, processing capabilities at the mill, transport equipment available, condition and extent of infrastructure, available capital, and environmental considerations (Norstebo and Johansen 2012).

As a processing facility increases in size and production potential, it requires greater volumes of fiber to remain productive. After a certain distance from the mill the cost of transportation becomes too great therefore reaching the maximum operating range of the facility; the lower the cost of transport per tonne per kilometer the farther fiber can be procured from a facility. The lowest cost of transportation is generally recognized when the total cost of skidding and forwarding, travelling portion of the trucking cost, and road construction and maintenance costs is at its lowest (McNally 1975).

1.2.2 Design and Specification Considerations

Load size and gross weight restrictions applied to logging trucks vary greatly between countries and even provinces (Norstebo and Johansen 2012). Structure and functionality of logging trucks are determined by timber harvesting method and needs of the mill (Norstebo and Johansen 2012). Material to be transported must be known when determining tractor and trailer specifications. When hauling roundwood, length must be known, as well as quantity moved per year, per season, duration of haul, and loading and unloading methods (McNally 1975). Roadway design also plays an important role in determining desired truck configuration. Influencing factors include road profile, length and slope of maximum adverse and favorable grades, surface material, base course material and thickness, width of travel surface and shoulders, and radius of curvatures (McNally 1975). Vehicle design constraints include dimension and weight regulations on public roads, safety regulations, sustained road speeds to max speed, availability of desirable vehicle components, availability of maintenance facilities, and well trained personnel (McNally 1975). Safety considerations include trailer stakes, load binders, travel speeds, and auxiliary braking systems. In addition, the federal Motor Vehicle Safety Act (1993) upholds set safety standards, which must be followed. Exhaust and crankcase emissions, noise levels, brake systems, occupant restraint systems and many more are covered under this federal legislation. The most economical size of hauling rig will vary with the length of haul; usually it is found that the longer the haul, the larger the optimum vehicle (McNally 1975). The shorter the haul the more loading and unloading time plays a role, too large of loads lead to delays for other trucks and equipment (McNally 1975).

1.2.3 Logging Truck Configurations

A tractor is a vehicle used for pulling a semi-trailer. These exist in many different forms; tandem and tridem drive tractors are most common in forest operations. (McNally 1975). The word "truck" refers to the body structure regardless of its from, tractor and trailer included (McNally 1975). The weight of road-ready truck without payload is referred to as tare weight, while gross vehicle weight [GVW] is the combined weight of truck and payload (McNally 1975). Single axles are as sounds, tandem comprises two axles with centers more then 48 but less then 96 inches apart, and tridem refers similarly to three axles (McNally 1975).

Straight trucks refer to automotive vehicles designed to carry weight on its own body structure (McNally 1975). A combination rig is composed of a tractor and one or more trailers (McNally 1975). A trailer train is a combination rig consisting of a tractor and two or more trailers (McNally 1975). The B-train refers to a combination rig where the rearmost trailer is attached by a fifth wheel assembly to the foremost semi-trailer (Government of Ontario 2014). Full trailer is one with axles placed near front and rear of the trailer; a pup trailer is one with axles located near the center of the trailer (McNally 1975). A dolly is a non-powered single, tandem or tridem axle unit fitted with a fifth wheel forming the front end support of a semi trailer and converting it to a full trailer (McNally 1975). It is removable and can be used widely in multi trailer rigs. The tandem axle jeep is a dolly used in many logging operations to increase payload and productivity (Blair 1999).

All regulation summaries for logging truck configurations used in Alberta can be found on the Alberta Forest Product Association website; these are produced by Alberta Transportation and specific for every configuration for both winter and summer weights (AFPA 2018). Configuration regulation summaries for the 10 axle B-train, 9 axle B-train, 8 axle B-train, 8 axle tandem Jeep, 8 axle quad, and 7 axle tri-tri were referenced for the completion of this thesis (AFPA 2018).

Parker (1995) conducted an extensive survey for the Forest Engineering Research Institute of Canada to determine future trends in log-hauling practices in western Canada. He concluded the super B-train was to become the most popular tractor/trailer configuration in Northern Alberta and tied for most popular with the tandem jeep / tandem pole trailer in Central Alberta. This can be attributed to the decline in the use of pole trailers. Therefore a larger portion of hauling configurations will have two or more articulation points. In addition, hauling distances were expected to rise from 3.2-5.2 hours to 4-6 hours in Central Alberta. Double Shifting is only expected to increase 23% to 30%. Shift length can vary from 10-12 hours in the winter and 13-15 hours in the summer. The maximum allowable shift is 15 hours, with 13 hours driving time.

1.2.4 Tractor Considerations

Horsepower is a measured unit equal to moving 33,000 pounds a distance of one foot in one minute; when referring to an internal combustion engine it is the work done per minute by the torque developed by the engine (McNally 1975). The horsepower rating quoted in North America is normally that delivered to the flywheel. While operating with fuel-system, water pump, lubricating oil pump and air cleaner; is referred to as gross horsepower (McNally 1995). Horsepower requirements are a function of gross vehicle weight, frontal area and road speed; this value is expressed as the sum of HP required overcoming rolling resistance, grade resistance, air resistance, chassis friction resistance and acceleration resistance (McNally 1975).

Engine torque is the measure of twisting effort exerted at the crankshaft by the engine; the unit measure is the foot-pound, which represents a force of one pound at the end of a one-foot arm (McNally 1975). Torque through the power train provides a measure of capability for the tractor to move a load as required. Torque is greatest at medium engine speeds and drops as maximum horsepower is reached, because fuel cannot move fast enough to fill each cylinder at high engine speeds (McNally 1975).

When purchasing a logging truck, it is important that the powertrain is adequate to carry the load, but also fuel efficient. For this reason engine size must be considered in depth (Jokai 2015). Larger engines can operate faster but at the expense of higher tare weight and increased fuel consumption (Jokai 2015). Changing the program in the engine control module (ECM) can increase power and torque and is an accepted solution for old rigs requiring a little more power. However, this comes at the expense of fuel economy (Jokai 2015).

The transmission translates the horsepower delivered by engine into the proper speed and torque required to move a given load (McNally 1975). Automatic and manual transmissions pose different challenges and advantages; however, these are dependent on driver experience.

Diesel engines compared to gasoline engines have several advantages. Less fuel is required to produce the same amount of horsepower; a diesel can idle on half the fuel volume used by a gasoline engine (McNally 1975). Higher compression ratios and higher sustained combustion pressures mean diesel engines are much heavier and more ruggedly built than gasoline engines. In turn, diesel engines are more durable, thus lowering maintenance cost, and allowing for longer life expectancy and higher availability (McNally 1975). Higher engine torque produced by diesel engines incurs heavier drive train components. Because of these reasons diesels have a higher associated purchase price but can be paid off through savings in fuel and maintenance expenses within a reasonable time (McNally 1975).

Selecting suitable rear truck axles is equally important in truck selection. Rear axles must meet the desired criteria for weight on rear axle, GVW, rear tire size, engine RPM, engine torque, transmission gear ratios, maximum speeds, maximum adverse grades and seasonal conditions (McNally 1975). Tridem drive units provide increased off-highway mobility over tandem units, thus offering operational and productivity benefits (Parker 2002). Tridem drive tractors show increased tractive capability between 28-55%, decreased cycle times, and increased payload capacity at a relatively similar operating and maintenance cost as tandem drive tractors (Parker 2002). However, tridem drive tractors experience increased levels of understeer. These levels are not sufficient enough to impede the ability to take tight turns on pavement (Parker 2002).

Amlin et al. (1995) studied a tridem drive tractor operated by 6 drivers that accumulated 185, 079 km over the trial period; all drivers reported tractive improvements that overcame the requirement for tire chains during challenging winter conditions. Not one driver reported steering response issues influenced but three driving axles. Roll stability was greatly enhanced on the tridem drive compared to tandem drive and drivers reported better braking performance.

1.2.5. Operating Cost

In the case of forest operations, tractor and trailer operating costs is generally accepted on an hourly basis rather than a mileage basis; this is more meaningful in many ways (McNally 1975). Because travelling one km on a tertiary logging road may cost more then several times as much on a primary highway. Likewise, time is irrelevant without a corresponding distance travelled. Often costs are determined as: variable cost and fixed cost. These can be combined after determining the ratio of each to determine total cost per shift or day (McNally 1975).

Fixed costs build up continuously regardless of whether the equipment is in use. These costs include capital depreciation, annual registration, insurance, interest on investment and operating labor, which includes direct wages and benefits (McNally 1975). Capital depreciation is the estimated life of the tractor or trailer expressed in hours, divided by the difference between delivered cost and residual value, this will be expressed as a cost per in use hour (McNally 1975). Interest forms a part of costs when owning any equipment and it should be considered when comparing equipment operating costs or when purchasing new equipment (McNally 1975). Operating labour cost is equal to the number of hours the driver is allocated and paid, it encompasses the standard hourly rate and number of overtime hours worked. Benefits are usually taken as a percentage of operator wage (McNally 1975). Travelling costs build up on a constant time basis, but only while equipment is traveling. These costs include fuel, oil, lubricants, tires, servicing, repairs, accidents and modifications (McNally 1975). Fuel consumption is dependent on a variety of factors such as specific engine, gross loads and hauling conditions; generally averages are determined by seasonality and working area (McNally 1995).

Oil and lubricants form a small cost and are easily estimated based on past experience. Polyalphaolephin base 75W90 synthetic oil is found to provide enhanced lubricating properties that reduce the power lost through friction in the gears. These properties will reduce fuel consumption and components wear on the machine (Ljubic and Chinn 1988). Special considerations should be made in regards to lubricants when operating in cold temperatures (Ljubic and Chinn 1988). Tire cost is highly variable due to its dependence on construction of the tire, tire load, inflation pressure, road surface, travel speed and ambient temperature (McNally 1975). Repair cost will increase steadily with age and includes parts, materials, labor and towing if needed (McNally 1975).

Smith and Tse (1977) compared the productivity of three weight classes of logging trucks. From this they drew several conclusions applicable to similar operations on how to enhance productivity. In order to increase productivity, the following steps can be taken. First, it is important to load every vehicle to capacity every trip. Second, increase truck speed by improving roads; this is a trade-off that must be evaluated comparing higher speeds and lower maintenance cost to that of building and maintaining roads. Third, reduction in delays at landings and improved dispatching play a major role in equipment sitting time. Fourth, frequent maintenance will extend life of vehicles. Lastly, two shifts daily operating cycle will reduce finance cost, insurance and license charges.

1.2.6. Seasonal Considerations

Winter weight premiums (WWP) are allowed in some provinces to help the forest sector increase yearly revenues and offset the impacts of load restrictions during spring thaw (Thiam and Bradley 2018). It has been proven that the slight increase in payload during the winter leads to a significant reduction in trucking cost by reducing the number of trips dramatically (Yi *et al.* 2016). Five provinces and two territories currently have winter weight policies: Alberta, Saskatchewan, Manitoba, Ontario, New Brunswick, the Yukon and Northwest Territories (Thiam and Bradley 2018). Alberta transportation uses a network of frost probes to determine frost depths; historically the 1.0 m mark has been the threshold for initiating the winter weight program (Thiam and Bradley 2018). The Technical Services Branch of Transport Engineering for Alberta Transportation develops maps of the Alberta highway network, specific to each truck configuration, which delineate winter weight premiums for specific configurations on each highway (Thiam and Bradley 2018). Highways are then given a color code; green routes have the highest allowance at up to 41% higher GVW, averaging around a 16% increase (Thiam and Bradley 2018). Blue is second, followed by yellow routes and last red where no WWP is applied. On average, WWP show an increase of 1.6 tonnes per axle across all configurations (Thiam and Bradley 2018). A cooperative study between FPinnovations, Alberta Transportation and Laval University found that minor pavement impacts occurred after frost reached a depth of 600 mm, for this reason they suggest changing the historic 1 m mark when initiating WWP to 700 mm (Thiam and Bradley 2018). Both Manitoba and Saskatchewan have adopted this threshold and initiate WPP at 750 mm frost depth.

Seasonality has a large influence on travel speed. A study conducted by Buley (2004) showed that log truck travel speeds near Grand Prairie Alberta were 26% faster during the winter season. This is because frozen roads were not as rough or dusty resulting in improved visibility (Buley 2004). Time of day, truck, driver and GVW had no influence on the study; time of year was the most influential variable on travel speed. For this reason, road stabilization techniques are warranted during the periods when roads are not frozen to improve cycle times and save costs (Buley 2004).

1.2.7 Cycle Time

Cycle time refers to the time it takes to go from the point of delivery to the forest product at place of harvest and back to the point of delivery. The nature of hauling forest products is covering a distance empty to reach the harvest area where fibre is loaded and then brought to the industry. This results in a load fulfillment of 50%. However, higher efficiency of load fulfillment can be achieved by finding cargo going the opposite direction (Ronnqvist 2014). This is referred to as a backhaul. Feasibility of a backhaul relies on location of harvest areas to routes that must be traveled empty, as well as the location of the second delivery point. If the harvest areas and second delivery point are at infeasible distances the backhaul may have no application. This is where a centralized sorting yard offers significant prospects.

2. MATERIALS AND METHODS

2.1. STUDY AREA AND TIME PERIOD

This study will take place on the Weyerhaeuser Pembina Forest Management Area [FMA]. Figure 1 displays the Pembina FMA. Configurations were assembled across six contractors based from both Edson and Drayton Valley, Alberta. Payloads were determined at both the Drayton Valley and Edson mill scales from May 1st 2017 to April 30th 2018. Kenworth and Western Star dealers located in Edmonton provided tractor purchase price. Castleton Industries LTD based out of Saltcoats Saskatchewan provided pricing for trailers recently sold in Alberta.

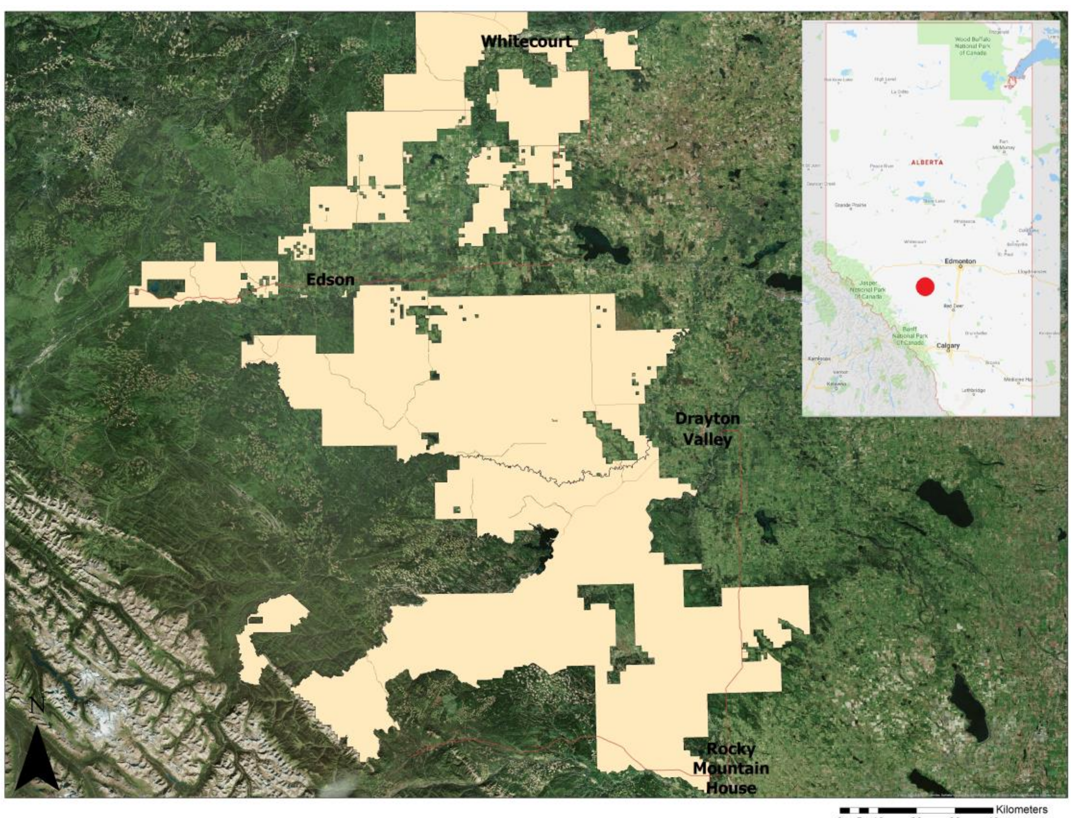

Figure 1. Reference map of the Pembina Forest Management Area (in beige).

2.2. CONFIGURATIONS EXAMINED

In this study 14 different tractor-trailer combinations were assembled into 6 configuration groups. This method of grouping streamlines the analysis and eliminates added complications from slight variations in the tractors and trailers. This makes the analysis more easily applicable to Weyerhaeuser's operation. The 6 groups represent added axles and different resulting payloads. All configurations used on the Pembina FMA haul 8 foot to 20 foot logs positioned lengthwise and dispersed over a series of bunks. The first group is the 7 axle tri-tri, which represents a tridem drive tractor and tridem trailer for both the wide and narrow track (Figure 2). The 8-axle Quad group represents the tridem drive tractor with quad axle trailer with lift axle (Figure 3). The 8 axle Jeep Tridem group is comprised of the reverse super B wide and narrow variants (Figure 4). The 8 axle Super B grouping represents both the wide and narrow track variant being pulled by a tandem drive tractor (Figure 5). The 9 axle group represents the 9 axle B trains with tridem drive tractor and tandem/tridem axle trailers both wide and narrow variants (Figure 6). The last configuration is the 10-axle King B; this is composed of a tridem drive truck and 2 tridem axle trailers (Figure 7).

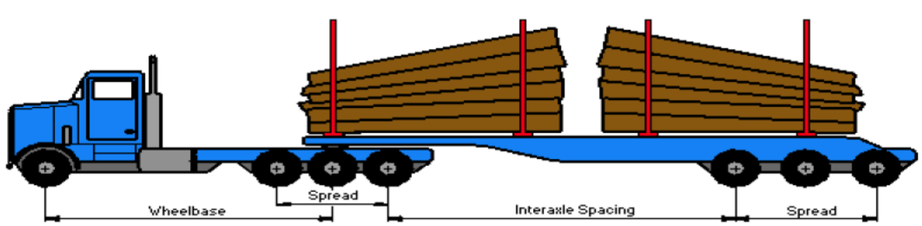

Figure 2. The 7 axle configuration, tri-drive tractor, with tridem axle trailer [7 ASTRITRIN]

Source: Alberta Government

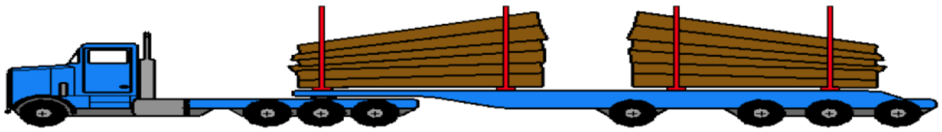

Figure 3. The 8 axle quad configuration, tridem drive tractor and quad axle trailer with one lift axle [8 ATRIQUADL]

Source: Alberta Government

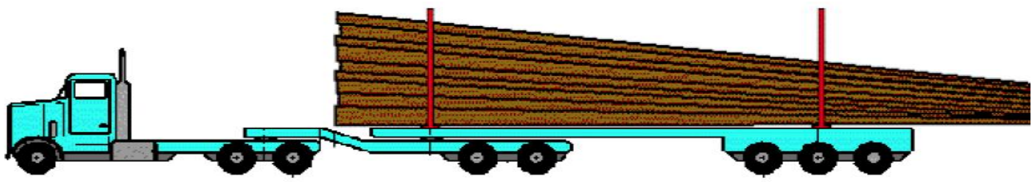

Figure 4. The 8-axle jeep tridem configuration, tandem drive tractor with tandem jeep and tridem axle semi trailer [8 ATANTANTR]

Source: Alberta Government

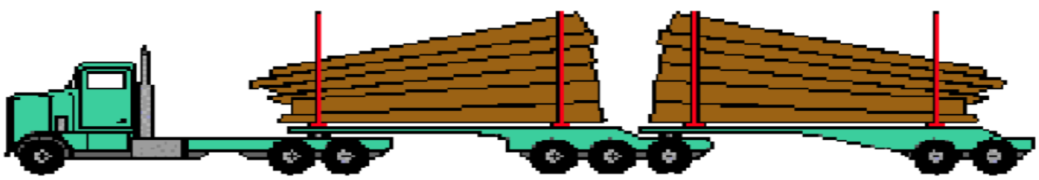

Figure 5. The 8 axle Super B configuration, tandem drive tractor with tridem and tandem axle trailers [8 ATRIB]

Source: Alberta Government

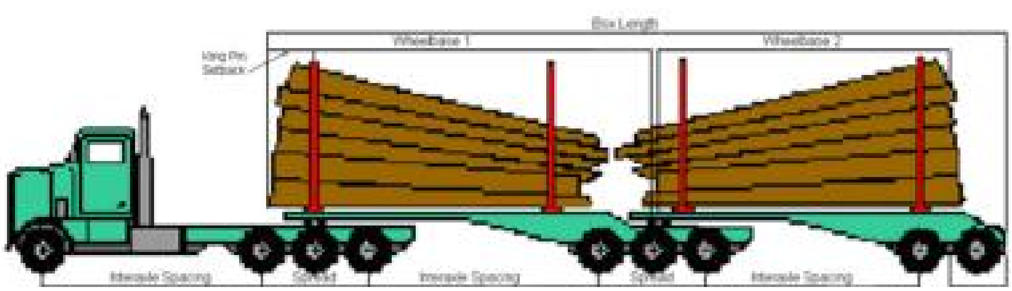

Figure 6. The 9 axle B-train configuration, tandem or tridem drive tractor with tandem or tridem and tandem or tridem trailers [9 AB]

Source: Alberta Government

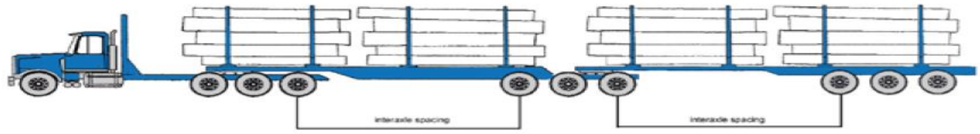

Figure 7. The 10 axle King-B configuration, tridem drive tractor with two-tridem axle trailers [10 AB]

Source: Alberta Government

2.3. THE RATE MODELS

Determining the elements of change from one configuration to the next is the second step to completing the cost analysis. The major inputs that change across each configuration are: payload, purchase price for both tractors and trailers, fuel consumption, tires, and maintenance cost. Hourly fuel consumption is taken from the Electronic Control Module [ECM] of every configuration. Fuel consumption has been recorded for less then a year but the values received are more than adequate for the purposes of this study. Every axle except the steer axle has 4 tires; the steer axle having 2 tires. Tires used on the tractor are typically of higher quality than those on the trailer; this means configuration cost of will vary based on number of axles present on the tractor versus the trailer. This can be determined using the diagrams found in Figures 2 to 7. For this study the Kenworth and Western Star dealerships located in Edmonton were contacted to determine pricing of a new tridem drive Western Star 4900 and tandem drive Kenworth T800 equipped and ready for a logging operation. Annual costs of parts and repair are necessary as well.

Payloads are recorded across the scales as trucks enter and exit the mill; these were compiled over the last timber year and averaged to determine the actual average payload in both summer and winter for each configuration. Within the rate model winter and summer payloads were blended to determine one payload value; roughly 68% of volume moved occurs under summer weights, therefore this value is used in this study.

Values and costs that remain the same for all configurations are the following: trips per day, cycle time, depreciation, down payment, resale value, interest rate, insurance, license, radio communications, tire chains, tools, permit, commercial vehicle inspection [CVIP], operator wage, overtime multiplier, holiday pay, Workers Compensation Board [WCB], Employment Insurance [EI], Canada Pension Plan [CPP], and lastly contactor profit margin. In addition the average cycle time used across the Pembina FMA will be used. Shift length and trips per day will be derived from the local averages as well.

2.4 POTENTIAL COST SAVINGS

To meet the objectives of this thesis the potential cost savings for Weyerhaeuser must be determined. The first step is determining the difference between calculated haul rates and existing base rates. Two base rates are used; one for Drayton Valley and another for Edson. This is a result of different roundwood entering each mill. Multiplying the savings in tonne/hour by the average cycle time gives the savings per tonne. Secondly, the savings per tonne must be converted to savings per m^3. Using a conversion factor of 0.750 tonne/m^3 for softwood delivered to Drayton Valley and 0.941 tonne/m^3 for hardwood delivered to Edson we can determine the savings per m^3. The potential cost savings per cubic metre is then multiplied by the annual volume delivered to each mill site: 930,000 m^3 to Drayton Valley and 300,000 m^3 to Edson.

3. RESULTS

This section will outline the determined fixed costs and variable costs between configurations, and the operating cost per hour and per tonne/hour for each of the six configurations. Finally, the potential cost savings for Weyerhaeuser when hauling with the most cost efficient trucking fleet.

For this study the Kenworth and Western Star dealerships located in Edmonton were contacted, the price of a new tridem drive Western Star 4900 equipped and ready for a logging operation was $252,000 after tax, this was the purchase price used for any configuration using a tridem drive tractor. The price of a tandem drive Kenworth T800 equipped and ready for a logging operation was roughly $215,250 after tax. After tax pricing for trailers amounted to the following; $148,355 for the 10 axle King B, $136,647 for the 9 axle and 8 axle B-trains, $109,999 for the quad trailer with lift axle, $86,670 for the tridem axle trailer and an additional $32,099 for a tandem jeep to make the 8-axle jeep configuration. Annual cost of parts and repair are set to 10% of the purchase price of that equipment. Fuel consumption follows the trend matching GVW; the higher the GVW the higher the rate of fuel consumption. Tire price was assigned a value $575 for trailer tires and $625 for tractor tires. Tires are replaced yearly; this change is accounted for within the model. All the changing variables and their associated configurations can be found in Table 1.

Table 1. Changing variables between all 6 configurations.

Configuration Group	Purchase Price		Fuel Consumption litres/hour	Parts and Repairs		
	Tractor	Trailer		Tractor	Trailer	Tires
10 axle King B	$252,000	$148,355	40	$25,200	$14,836	38
9 axle B-train	$252,000	$136,465	38	$25,200	$13,647	34
8 axle B-train	$215,250	$136,465	36	$21,525	$13,647	30
8 axle Quad	$252,000	$109,999	36	$25,000	$11,000	30
8 axle Jeep Tridem	$215,250	$118,769	36	$21,525	$11,877	30
7 axle tri-tri	$252,000	$86,670	35	$25,000	$8,667	26

Payloads were averaged over the course of one year for configurations crossing the mill scales. These payloads were then divided into summer and winter weight categories at both the Drayton Valley and Edson mills. This provides a realistic average payload based on seasonality and destination. A blend of 68% summer weights is then applied to the payloads to determine the annual average for every configuration. These payloads are shown in Table 2 and Figure 8.

Table 2. Average summer and winter payloads (kg) for all 6 configuration groups to both Edson and Drayton Valley mill.

	Edson		Drayton Valley	
Configuration Group	Summer	Winter	Summer	Winter
10 axle King B	48,409	55,977	51,570	60,071
9 axle B-train	42,072	47,336	45,434	50,976
8 axle B-train	38,899	41,954	39,633	46,630
8 axle Quad	38,597	39,800	38,920	42,196
8 axle Jeep Tridem	38,178	40,335	39,934	42,939
7 axle tri-tri	39,625	41,044	32,826	40,557

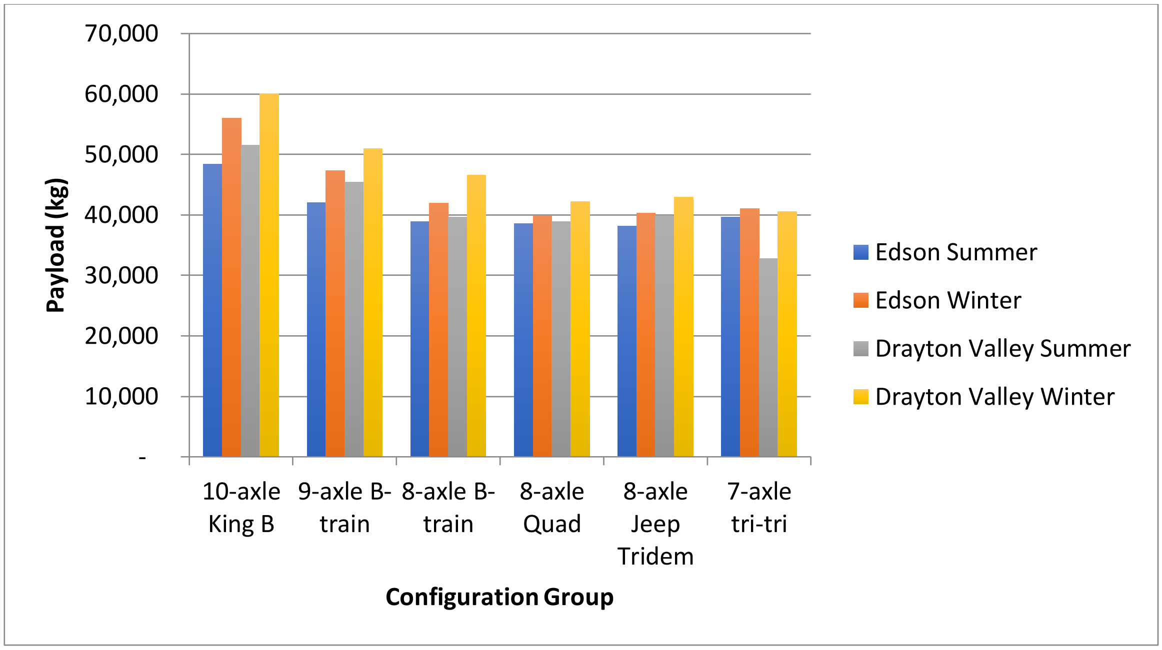

Figure 8. Average summer and winter payloads (kg) for all 6 configuration groups to both Edson and Drayton Valley mill.

The inputs that remain fixed for all 6 configurations are found in Table 3. The depreciation of equipment was determined to be 7 years for tractors and 10 years for trailers. A down-payment value of 20% was used for both tractor and trailer. A resale value of 20% for both tractor and trailer was applied. An interest rate of 5.5% was applied. Insurance rate of 4% of purchase price is required along with licensing fee of $3,456.00, $820 in permits, and $800 for CVIP inspections. Tire chains, ropes and tools were given a cost of $2,500. Operator wage is $35.00 per hour with an overtime multiplier of 16.6%, 5% holiday pay, 3% WCB, and maximum annual values of $1,171 for EI and $2,564 for CPP were applied.

Table 3. Fixed inputs used for all six configuration groups.

	Common	Tractor	Trailer
Depreciation Life (yrs)	-	7	10
Downpayment	-	20%	20%
Resale Value	-	20%	20%
Interest Rate - %	5.5%	-	-
Insurance - % of capital	4.0%	-	-
License	$3,456.00	-	-
Radio/cell ($/season)	$1,000.00	-	-
Tire chains, ropes, etc	$2,000.00	-	-
Tools	$500.00	-	-
Permit costs	$820.00	-	-
CVIP inspection	-	$400.00	$400.00
Base Wage ($/hr)	$35.00	-	-
Overtime - Multiplier	16.6%	-	-
Holiday Pay	5.0%	-	-
WCB	3.0%	-	-
EI - maximum/yr/person	$1,171.00	-	-
CPP - maximum/yr/person	$2,564.00	-	-

The operating cost per tonne/hour for all 6 configurations fall within a $1.10 range of one another. When hauling to Drayton Valley the lowest operating cost is for the 10 axle king B at an operating cost of $2.79 per tonne/hour and the highest being the 7 axle tri-tri at $3.88 per tonne/hour. When hauling to Edson the configuration yielding the lowest operating cost is again the 10 axle King B at $2.98 per tonne/hour and the highest is the 8 axle quad at $3.61 per tonne/hour. The exact values of operating cost per tonne/hour when hauling to Drayton Valley and Edson can be found in Table 4. Operating cost per tonne/hour can be seen graphically in Figure 9.

Table 4. Operational cost per tonne/hour for all configurations hauling to either Drayton Valley or Edson.

	10 axle King B	9 axle B-train	8 axle B-train	8 axle Quad	8 axle Jeep	7 axle tri-tri
Drayton Valley	$2.79	$3.11	$3.33	$3.52	$3.34	$3.88
Edson	$2.98	$3.36	$3.49	$3.61	$3.51	$3.39

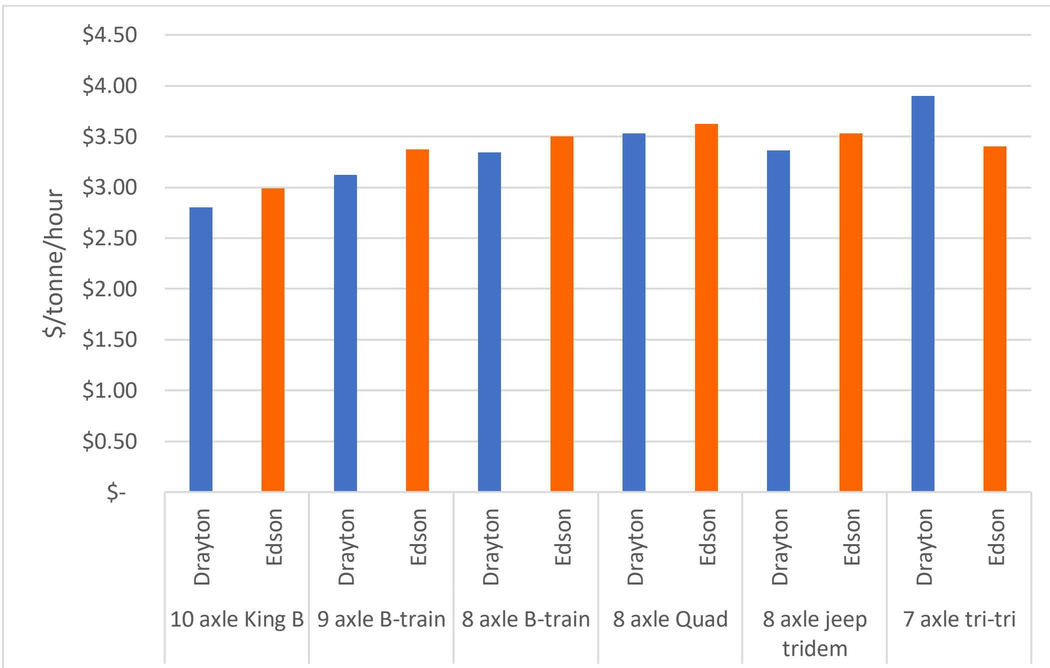

Figure 9. Operating cost per tonne/hour for all configurations travelling to either Edson or Drayton Valley.

The operating cost per scheduled machine hour [SMH0 yielded the following results; these results can be found in Table 5 and Figure 10. The 10 axle King B had the highest operating cost followed by the 9 axle B train, the 8 axle quad, the 8 axle jeep tridem, the 8 axle B-train and lastly the 7 axle tri-tri. The operating cost per SMH was $151.45, $146.98, $140.90, $139.72, $139.09 and $136.02 respectively.

Table 5. The operating cost in $/SMH for all 6 configurations.

	10 axle King B	9 axle B-train	8 axle B-train	8 axle Quad	8 axle Jeep	7 axle tri-tri
$/SMH	$151.45	$146.98	$139.09	$140.90	$139.72	$136.02

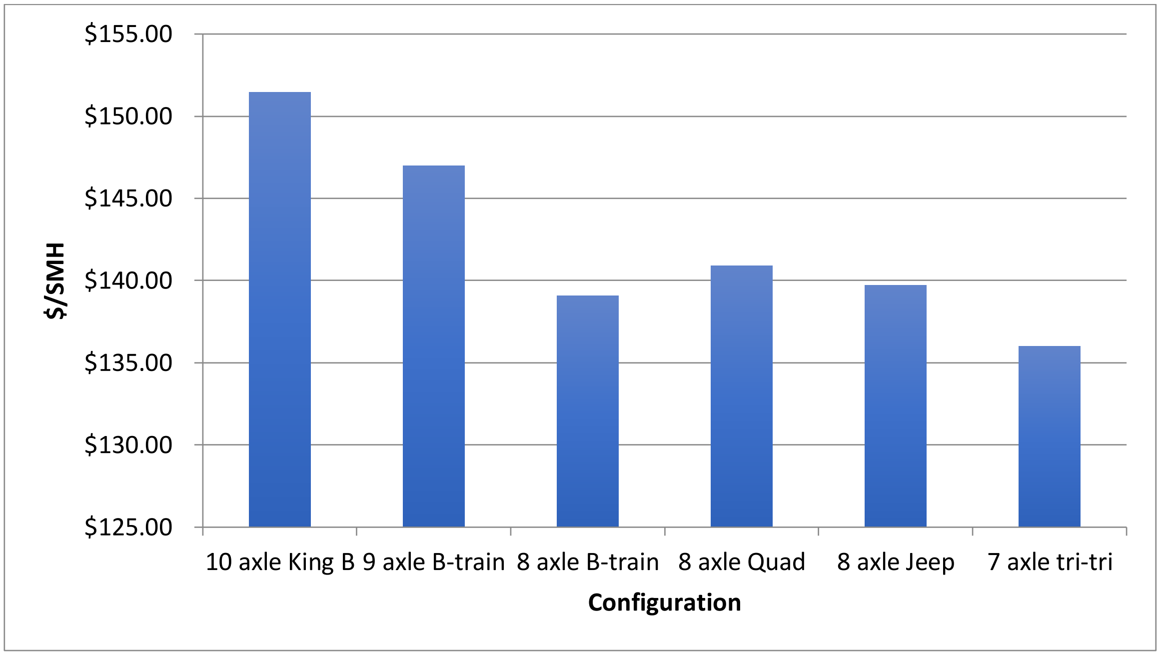

Figure 10. Operating cost in $/SMH for all 6 configurations.

The 10 axle King B proved the most cost effective truck configuration, Table 6 shows the savings per tonne, savings per cubic metre and lastly the potential annual cost savings to Weyerhaeuser's Pembina Timberlands. A potential savings of $3,950,669 per year was determined when hauling with a fleet composed of the 10 axle King B.

Table 6. Potential cost savings to Weyerhaeuser's Pembina Timberlands by hauling with the most cost effective trucking fleet.

	Drayton Valley	Edson
$/tonne/hour	$2.79	$2.98
Savings/tonne	$4.02	$4.07
Savings/m3	$3.01	$3.83
Total savings	$2,802,555.00	$1,148,114.10

4. DISCU SSION

The findings of this study offer significant opportunity for both Weyerhaeuser's Pembina Timberlands and its contractors. The most significant outcome of this analysis is the opportunity of cost savings up to $3,950,669 annually. This is dependent on a variety of factors that will be examined further in the following section. It is important to consider model inputs that may not reflect reality to better understand where improvements can be made on the ground to achieve the optimal transportation system for wood fiber.

4.1 TRACTOR AND TRAILER CONSIDERATIONS

Firstly, it is important to consider the ever changing nature of such a problem, for example, currency fluctuations, inflation on the dollar and imposed steel tariffs can have significant impacts on tractor and trailer pricing. Results will vary depending on the desired make and model of tractor and trailer as well. For this study the Kenworth and Western Star dealerships located in Edmonton were contacted, the price of a new tridem drive Western Star 4900 equipped and ready for a logging operation was roughly $240,000 before tax, this was the purchase price used for any configuration using a tridem drive tractor. The price of a tandem drive Kenworth T800 equipped and ready for a logging operation was roughly $205,000 before tax. Alberta has no Provincial Sales Tax [PST] only the Goods and Service Tax [GST] of 5%. This results in the price of $252,000 for a tridem drive WS4900 and $215,250 for a tandem Kenworth T800. The Kenworth T800 and Western Star 4900 are both common tractors used in logging operations on the

Pembina FMA. Another important consideration is the absence of sleepers on these particular tractors; the addition of such a feature can increase purchase price by nearly $10,000. The price of tractors will vary depending on the customer and the dealer, just like buying a car you may have a better deal depending on your relationship, past purchases and desired machine. For this study the T800 and WS4900 will do.

Castleton Industries LTD is based out of Saskatchewan; they were contacted to provide purchase prices for all trailers used in this study. They generously provided pricing for trailers they had recently sold in Alberta. Similar to the tractors there is considerable variation in pricing between manufacturers. Castleton Industries receives feedback from its customers to ensure pricing remains competitive for out of province sales. Contractors hauling for Weyerhaeuser using the 10 axle King B have begun implementing central tire inflation [CTI]; for this study the additional cost of CTI was not included. The 9 axle B train assumes a tridem drive tractor with tridem and tandem trailers; this is typical in Weyerhaeuser's operation. This slightly reduces the purchase price of the trailer but at the expense of additional payload. The 8 axle B train uses the same tridem and tandem trailers as the 9 axle B train, however a tandem tractor substitutes the tridem drive. This provides a good alternative for contractors who have tandem drive tractors with life remaining that wish to enhance payload without having to purchase a new tractor. Similarly, the 8 axle jeep tridem configuration allows for a tandem drive truck to attach a tandem jeep and render its tridem trailer to a full trailer offering additional payload.

When examining Figure 8 we can see a dramatic decrease in payload on the 7 axle tri-tri configuration when transporting to the Drayton Valley mill. This is a result of a contractor who predominantly utilizes 7 axle tri-tri configurations with an on board log loader. This increases the tare weight of the vehicle thus reducing the payload. This contractor is based out of Drayton Valley and harvests predominantly in the southern portion of the FMA leading to more volume of softwood being delivered by their 7 axle configurations.

4.2 CYCLE TIME

Cycle times range across the FMA and can vary between 2 to 8 hours, cycle time is ever increasing (Parker 1995). For this study the annual average cycle time of 4.9 hours was used. This 4.9 hour cycle time includes delays like loading, unloading and time lost crossing the scales at mill. In order to simulate a 12-hour day the trip per day value was set to 2.5. These inputs simply represent the annual averages, which are 12-hours driving per day and 4.9 hour cycle time. Weyerhaeuser currently uses sorting yards dispersed across the Pembina FMA for a variety of reasons. One added benefit of these sorting yards it the ability to maximize trips per day when cycle time from the harvest area poses a problem. The use of these sorting yards allows for a more effective log haul as it provides alternative destinations when a final trip to the mill may be infeasible.

The nature of hauling forest products is covering a distance empty to reach the harvest area where fiber is loaded and then brought to the industry. This results in a load fulfillment of 50%. However, higher efficiency of load fulfillment can be achieved by finding cargo going the opposite direction (Ronnqvist 2014). The opportunity of implementing a backhaul program could drastically increase efficiency of the Pembina haul operation; implementation of such a program could theoretically result in trucks hauling twice as much volume in the same amount of time if suitable hauling routes can be determined. The Pembina FMA offers good opportunities to implement such a system as it has two mills, one located at the north (Edson) of the FMA and one located to the east (Drayton Valley). This means that frequently empty trucks are passing within a reasonable distance to other logging sites and perhaps even the other mill when headed back to retrieve another load. This is a complex issue to tackle but again offers potential room for improvement within Weyerhaeuser Pembina's log haul. With the use of sorting yards proving successful Weyerhaeuser has already made the first step in potentially incorporating a backhaul program into their log hauling operations. This again poses significant benefit to both contractors and Weyerhaeuser.

4.2 OPERATING COST

Upon comparing Figure 8 and Figure 10 there is noticeable correlation between payload and hourly operating cost. The higher the payload the higher the operating cost, since higher GVW requires a larger and more expensive tractor and trailer, and higher fuel consumption, parts and maintenance. The 10 axle King B has the highest operating cost at $151.45/hour, but also has the highest average payload. This resulted in the lowest operating cost per tonne/hour of any configuration at $2.79 hauling softwood to Drayton Valley and $2.98 hauling hardwood to Edson. The 9 axle B-train has an operating cost of $3.11 per tonne/hour when hauling to Drayton Valley and $3.36 per tonne/hour when hauling to Edson, as well as an hourly operating cost of $146.98. Third, is the 8 axle B-train posting an hourly operating cost of $139.09 per hour, $3.33 per tonne/hour hauling softwood and $3.49 per tonne/hour hauling hardwood. Next was the 8 axle jeep tridem which achieved an hourly operational cost of $139.72, operational cost of $3.35 per tonne hour to Drayton Valley and $3.52 per tonne hour to Edson. The 8 axle quad has an hourly operating cost of $140.90, an operational cost of $3.52 per tonne hour hauling softwood and $3.61 per tonne/hour hauling hardwood. This makes the 8 axle B train the most cost effective configuration using a tandem tractor. Lastly was the 7 axle tri-tri which posted the lowest hourly operating cost of $136.02 and the highest operational cost hauling to Drayton Valley at $3.88 per tonne/hour. However, it resulted in an operational cost of $3.39 per tonne/hour hauling to Edson. This is peculiar as every other configuration posted a higher operational cost hauling hardwood, as the density is much higher then that of softwood. This could be directly associated to the significantly higher average payload of 7 axle tri-tri configurations hauling to Edson which can be seen in table 2 and figure 8.

4.3 POTENTIAL COST SAVINGS

To meet the objectives of this thesis the potential cost savings to Weyerhaeuser's Pembina Timberlands was determined when hauling with the most cost effective trucking fleet. The most cost effective configuration found in this study was the 10 axle King B. By multiplying the potential savings per cubic meter by the total volume moved to either mill annually the potential cost savings of $3,950,669 annually was determined. This is a very large value and the reason for Weyerhaeuser's interest in partaking in this thesis. To achieve these potential savings it would require a transition of the current fleet of 90 trucks to one composed entirely of 10 axle King B's. This benefits both Weyerhaeuser and its contractors as such a transition would result in lower haul rates, while maintaining the same profit margins for its contractors. In addition less trucks will be needed to haul the same volume thus requiring less drivers, which are currently in high demand and limited supply.

5. CONCLUSION

The results showcase a comparison of the current configurations being used on the Pembina FMA. Although the differences may seem minimal at first when comparing the operational cost. When extrapolated across the entirety of volume moved annually some significant results emerge.

The objective of this thesis was to determine the most cost effective log truck configuration for Weyerhaeuser's Pembina Timberlands when moving roundwood to its Edson and Drayton Valley mills. This study determined that the optimal configuration was the 10 axle King B. This configuration had the highest hourly operating cost at $151.45/hour yet the lowest operational cost per tonne/hour at $2.79 hauling softwood to Drayton Valley and $2.98 hauling hardwood to Edson. A potential savings of $3,950,669 annually was determined if Weyerhaeuser were to possess the most cost effective trucking fleet. This is a significant value and creates incentive for Weyerhaeuser and its contractors to begin a transition to utilizing more cost effective configurations. To ensure the economical profitability of Weyerhaeuser and its contractors they must look to increase slight efficiencies wherever possible to reduce costs. This is an important belief to Weyerhaeuser since launching its OpX initiative that aims to improve every aspect of the supply chain making the company and its affiliates more efficient and economically successful as a whole. For this reason the suggestion of potentially implementing a backhaul was made as again it could render the Pembina log haul slightly more efficient by reducing the amount of empty driving time.

This study fulfilled its objectives in determining the most cost effective log truck configuration for Weyerhaeuser's Pembina Timberland as well as the potential savings by implementing the most cost effective fleet. It addressed potential barriers and further room for improvement within the Pembina log haul. These findings will allow the parties involved to increase operational efficiency thus lowering costs and saving time.

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APPENDICES

Appendix 1. Rate model for the 10 axle King B hauling to Drayton Valley.

ASSUMPTIONS	Common to ALL	Tractor	Trailer	Total Unit
Average Distance: km				
Summer		210	210	210
Winter		210	210	210
Average Tonnes/Load				
Summer		51.57	51.57	51.57
Winter		60.07	60.07	60.07
Average Cycle Time				
Summer		4.9	4.9	4.9
Winter		4.9	4.9	4.9
Trips per Day (# of cycles)				
Summer		2.5	2.5	2.5
Winter		2.5	2.5	2.5
Available Haul Days				
Summer		135	135	135
Winter		70	70	70
		205	205	205
Fixed Costs:				
Purchase Price - $		252,000	148,355	400,355
Depreciation Life (yrs)		7	10	
Downpayment - $		50,400	29,671	80,071
Resale Value - $		50,400	17,803	68,203
Interest Rate - %	5.50%			
Insurance - % of capital	4.00%			
Overhead				
License - $	3,456			
Radio/cell - $/season	1,000			
Tire chains, ropes, etc	2,000			
Tools - $	500			
Permit costs ($)	820			
CVIP inspection - $		400	400	800
Variable Costs:				
Labor:				
Base Wage - Operator $/hr		35.00		
Overtime - Multiplier	16.6%			
Holiday Pay - %	5.0%			
WCB - %	3.0%			
EI - maximum/yr/person	$1,171			
CPP - maximum/yr/person	$2,564			
Benefits - %	0.0%			
# of operators				
summer		1		
winter		1		
Machine:				
Fuel				
- Litres/100km				
- Litres/hr		40.0		
- $/Litre		0.86		
Lubes - % of fuel $		8.00%		
DEF - % of fuel $		5.00%		
Repair $/yr on parts & labor		25,200	14,836	40,036
Tires				
Tires used/yr		14	24	38
$/tire		625	575	

Appendix 2. Rate model for the 10 axle King B hauling to Edson.

ASSUMPTIONS	Common to ALL	Tractor	Trailer	Total Unit
Average Distance: km				
Summer		210	210	210
Winter		210	210	210
Average Tonnes/Load				
Summer		48.41	48.41	48.41
Winter		55.98	55.98	55.98
Average Cycle Time				
Summer		4.9	4.9	4.9
Winter		4.9	4.9	4.9
Trips per Day (# of cycles)				
Summer		2.5	2.5	2.5
Winter		2.5	2.5	2.5
Available Haul Days				
Summer		135	135	135
Winter		70	70	70
		205	205	205
Fixed Costs:				
Purchase Price - $		252,000	148,355	400,355
Depreciation Life (yrs)		7	10	
Downpayment - $		50,400	29,671	80,071
Resale Value - $		50,400	17,803	68,203
Interest Rate - %	5.50%			
Insurance - % of capital	4.00%			
Overhead				
License - $	3,456			
Radio/cell - $/season	1,000			
Tire chains, ropes, etc	2,000			
Tools - $	500			
Permit costs ($)	820			
CVIP inspection - $		400	400	800
Variable Costs:				
Labor:				
Base Wage - Operator $/hr		35.00		
Overtime - Multiplier	16.6%			
Holiday Pay - %	5.0%			
WCB - %	3.0%			
EI - maximum/yr/person	$1,171			
CPP - maximum/yr/person	$2,564			
Benefits - %	0.0%			
# of operators				
summer		1		
winter		1		
Machine:				
Fuel				
- Litres/100km				
- Litres/hr		40.0		
- $/Litre		0.86		
Lubes - % of fuel $		8.00%		
DEF - % of fuel $		5.00%		
Repair $/yr on parts & labor		25,200	14,836	40,036
Tires				
Tires used/yr		14	24	38
$/tire		625	575	

Appendix 3. Rate model for the 9 axle B-train hauling to Drayton Valley.

ASSUMPTIONS	Common to ALL	Tractor	Trailer	Total Unit
Average Distance: km				
Summer		210	210	210
Winter		210	210	210
Average Tonnes/Load				
Summer		45.43	45.43	45.43
Winter		50.98	50.98	50.98
Average Cycle Time				
Summer		4.9	4.9	4.9
Winter		4.9	4.9	4.9
Trips per Day (# of cycles)				
Summer		2.5	2.5	2.5
Winter		2.5	2.5	2.5
Available Haul Days				
Summer		135	135	135
Winter		70	70	70
		205	205	205
Fixed Costs:				
Purchase Price - $		252,000	136,465	388,465
Depreciation Life (yrs)		7	10	
Downpayment - $		50,400	27,293	77,693
Resale Value - $		50,400	16,376	66,776
Interest Rate - %	5.50%			
Insurance - % of capital	4.00%			
Overhead				
License - $	3,456			
Radio/cell - $/season	1,000			
Tire chains, ropes, etc	2,000			
Tools - $	500			
Permit costs ($)	820			
CVIP inspection - $		400	400	800
Variable Costs:				
Labor:				
Base Wage - Operator $/hr		35.00		
Overtime - Multiplier	16.6%			
Holiday Pay - %	5.0%			
WCB - %	3.0%			
EI - maximum/yr/person	$1,171			
CPP - maximum/yr/person	$2,564			
Benefits - %	0.0%			
# of operators				
summer		1		
winter		1		
Machine:				
Fuel				
- Litres/100km				
- Litres/hr		38.0		
- $/Litre		0.86		
Lubes - % of fuel $		8.00%		
DEF - % of fuel $		5.00%		
Repair $/yr on parts & labor		25,200	13,647	38,847
Tires				
Tires used/yr		14	20	34
$/tire		625	575	

Appendix 4. Rate model for the 9 axle B-train hauling to Edson.

ASSUMPTIONS	Common to ALL	Tractor	Trailer	Total Unit
Average Distance: km				
Summer		210	210	210
Winter		210	210	210
Average Tonnes/Load				
Summer		42.07	42.07	42.07
Winter		47.34	47.34	47.34
Average Cycle Time				
Summer		4.9	4.9	4.9
Winter		4.9	4.9	4.9
Trips per Day (# of cycles)				
Summer		2.5	2.5	2.5
Winter		2.5	2.5	2.5
Available Haul Days				
Summer		135	135	135
Winter		70	70	70
		205	205	205
Fixed Costs:				
Purchase Price - $		252,000	136,465	388,465
Depreciation Life (yrs)		7	10	
Downpayment - $		50,400	27,293	77,693
Resale Value - $		50,400	16,376	66,776
Interest Rate - %	5.50%			
Insurance - % of capital	4.00%			
Overhead				
License - $	3,456			
Radio/cell - $/season	1,000			
Tire chains, ropes, etc	2,000			
Tools - $	500			
Permit costs ($)	820			
CVIP inspection - $		400	400	800
Variable Costs:				
Labor:				
Base Wage - Operator $/hr		35.00		
Overtime - Multiplier	16.6%			
Holiday Pay - %	5.0%			
WCB - %	3.0%			
EI - maximum/yr/person	$1,171			
CPP - maximum/yr/person	$2,564			
Benefits - %	0.0%			
# of operators				
summer		1		
winter		1		
Machine:				
Fuel				
- Litres/100km				
- Litres/hr		38.0		
- $/Litre		0.86		
Lubes - % of fuel $		8.00%		
DEF - % of fuel $		5.00%		
Repair $/yr on parts & labor		25,200	13,647	38,847
Tires				
Tires used/yr		14	20	34
$/tire		625	575	

Appendix 5. Rate model for the 8 axle B-train hauling to Drayton Valley.

ASSUMPTIONS	Common to ALL	Tractor	Trailer	Total Unit
Average Distance: km				
Summer		210	210	210
Winter		210	210	210
Average Tonnes/Load				
Summer		39.63	39.63	39.63
Winter		46.63	46.63	46.63
Average Cycle Time				
Summer		4.9	4.9	4.9
Winter		4.9	4.9	4.9
Trips per Day (# of cycles)				
Summer		2.5	2.5	2.5
Winter		2.5	2.5	2.5
Available Haul Days				
Summer		135	135	135
Winter		70	70	70
		205	205	205
Fixed Costs:				
Purchase Price - $		215,250	136,465	351,715
Depreciation Life (yrs)		7	10	
Downpayment - $		43,050	27,293	70,343
Resale Value - $		43,050	16,376	59,426
Interest Rate - %	5.50%			
Insurance - % of capital	4.00%			
Overhead				
License - $	3,456			
Radio/cell - $/season	1,000			
Tire chains, ropes, etc	2,000			
Tools - $	500			
Permit costs ($)	820			
CVIP inspection - $		400	400	800
Variable Costs:				
Labor:				
Base Wage - Operator $/hr		35.00		
Overtime - Multiplier	16.6%			
Holiday Pay - %	5.0%			
WCB - %	3.0%			
EI - maximum/yr/person	$1,171			
CPP - maximum/yr/person	$2,564			
Benefits - %	0.0%			
# of operators				
summer		1		
winter		1		
Machine:				
Fuel				
- Litres/100km				
- Litres/hr		36.0		
- $/Litre		0.86		
Lubes - % of fuel $		8.00%		
DEF - % of fuel $		5.00%		
Repair $/yr on parts & labor		21,525	13,647	35,172
Tires				
Tires used/yr		10	20	30
$/tire		625	575	

Appendix 6. Rate model for the 8 axle B-train hauling to Edson.

ASSUMPTIONS	Common to ALL	Tractor	Trailer	Total Unit
Average Distance: km				
Summer		210	210	210
Winter		210	210	210
Average Tonnes/Load				
Summer		38.80	38.80	38.80
Winter		41.95	41.95	41.95
Average Cycle Time				
Summer		4.9	4.9	4.9
Winter		4.9	4.9	4.9
Trips per Day (# of cycles)				
Summer		2.5	2.5	2.5
Winter		2.5	2.5	2.5
Available Haul Days				
Summer		135	135	135
Winter		70	70	70
		205	205	205
Fixed Costs:				
Purchase Price - $		215,250	136,465	351,715
Depreciation Life (yrs)		7	10	
Downpayment - $		43,050	27,293	70,343
Resale Value - $		43,050	16,376	59,426
Interest Rate - %	5.50%			
Insurance - % of capital	4.00%			
Overhead				
License - $	3,456			
Radio/cell - $/season	1,000			
Tire chains, ropes, etc	2,000			
Tools - $	500			
Permit costs ($)	820			
CVIP inspection - $		400	400	800
Variable Costs:				
Labor:				
Base Wage - Operator $/hr		35.00		
Overtime - Multiplier	16.6%			
Holiday Pay - %	5.0%			
WCB - %	3.0%			
EI - maximum/yr/person	$1,171			
CPP - maximum/yr/person	$2,564			
Benefits - %	0.0%			
# of operators				
summer		1		
winter		1		
Machine:				
Fuel				
- Litres/100km				
- Litres/hr		36.0		
- $/Litre		0.86		
Lubes - % of fuel $		8.00%		
DEF - % of fuel $		5.00%		
Repair $/yr on parts & labor		21,525	13,647	35,172
Tires				
Tires used/yr		10	20	30
$/tire		625	575	

Appendix 7. Rate model for the 8 axle Quad hauling to Drayton Valley.

ASSUMPTIONS	Common to ALL	Tractor	Trailer	Total Unit
Average Distance: km				
Summer		210	210	210
Winter		210	210	210
Average Tonnes/Load				
Summer		38.92	38.92	38.92
Winter		42.20	42.20	42.20
Average Cycle Time				
Summer		4.9	4.9	4.9
Winter		4.9	4.9	4.9
Trips per Day (# of cycles)				
Summer		2.5	2.5	2.5
Winter		2.5	2.5	2.5
Available Haul Days				
Summer		135	135	135
Winter		70	70	70
		205	205	205
Fixed Costs:				
Purchase Price - $		252,000	109,999	361,999
Depreciation Life (yrs)		7	10	
Downpayment - $		50,400	22,000	72,400
Resale Value - $		50,400	13,200	63,600
Interest Rate - %	5.50%			
Insurance - % of capital	4.00%			
Overhead				
License - $	3,456			
Radio/cell - $/season	1,000			
Tire chains, ropes, etc	2,000			
Tools - $	500			
Permit costs ($)	820			
CVIP inspection - $		400	400	800
Variable Costs:				
Labor:				
Base Wage - Operator $/hr		35.00		
Overtime - Multiplier	16.6%			
Holiday Pay - %	5.0%			
WCB - %	3.0%			
EI - maximum/yr/person	$1,171			
CPP - maximum/yr/person	$2,564			
Benefits - %	0.0%			
# of operators				
summer		1		
winter		1		
Machine:				
Fuel				
- Litres/100km				
- Litres/hr		36.0		
- $/Litre		0.86		
Lubes - % of fuel $		8.00%		
DEF - % of fuel $		5.00%		
Repair $/yr on parts & labor		25,200	11,000	36,200
Tires				
Tires used/yr		14	16	30
$/tire		625	575	

Appendix 8. Rate model for the 8 axle Quad hauling to Edson.

ASSUMPTIONS	Common to ALL	Tractor	Trailer	Total Unit
Average Distance: km				
Summer		210	210	210
Winter		210	210	210
Average Tonnes/Load				
Summer		38.50	38.50	38.50
Winter		39.80	39.80	39.80
Average Cycle Time				
Summer		4.9	4.9	4.9
Winter		4.9	4.9	4.9
Trips per Day (# of cycles)				
Summer		2.5	2.5	2.5
Winter		2.5	2.5	2.5
Available Haul Days				
Summer		135	135	135
Winter		70	70	70
		205	205	205
Fixed Costs:				
Purchase Price - $		252,000	109,999	361,999
Depreciation Life (yrs)		7	10	
Downpayment - $		50,400	22,000	72,400
Resale Value - $		50,400	13,200	63,600
Interest Rate - %	5.50%			
Insurance - % of capital	4.00%			
Overhead				
License - $	3,456			
Radio/cell - $/season	1,000			
Tire chains, ropes, etc	2,000			
Tools - $	500			
Permit costs ($)	820			
CVIP inspection - $		400	400	800
Variable Costs:				
Labor:				
Base Wage - Operator $/hr		35.00		
Overtime - Multiplier	16.6%			
Holiday Pay - %	5.0%			
WCB - %	3.0%			
EI - maximum/yr/person	$1,171			
CPP - maximum/yr/person	$2,564			
Benefits - %	0.0%			
# of operators				
summer		1		
winter		1		
Machine:				
Fuel				
- Litres/100km				
- Litres/hr		36.0		
- $/Litre		0.86		
Lubes - % of fuel $		8.00%		
DEF - % of fuel $		5.00%		
Repair $/yr on parts & labor		25,200	11,000	36,200
Tires				
Tires used/yr		14	16	30
$/tire		625	575	

Appendix 9. Rate model for the 8 axle jeep tridem hauling to Drayton Valley.

ASSUMPTIONS	Common to ALL	Tractor	Trailer	Total Unit
Average Distance: km				
Summer		210	210	210
Winter		210	210	210
Average Tonnes/Load				
Summer		39.93	39.93	39.93
Winter		42.94	42.94	42.94
Average Cycle Time				
Summer		4.9	4.9	4.9
Winter		4.9	4.9	4.9
Trips per Day (# of cycles)				
Summer		2.5	2.5	2.5
Winter		2.5	2.5	2.5
Available Haul Days				
Summer		135	135	135
Winter		70	70	70
		205	205	205
Fixed Costs:				
Purchase Price - $		215,250	118,769	334,019
Depreciation Life (yrs)		7	10	
Downpayment - $		43,050	23,754	66,804
Resale Value - $		43,050	14,252	57,302
Interest Rate - %	5.50%			
Insurance - % of capital	4.00%			
Overhead				
License - $	3,456			
Radio/cell - $/season	1,000			
Tire chains, ropes, etc	2,000			
Tools - $	500			
Permit costs ($)	820			
CVIP inspection - $		400	400	800
Variable Costs:				
Labor:				
Base Wage - Operator $/hr		35.00		
Overtime - Multiplier	16.6%			
Holiday Pay - %	5.0%			
WCB - %	3.0%			
EI - maximum/yr/person	$1,171			
CPP - maximum/yr/person	$2,564			
Benefits - %	0.0%			
# of operators				
summer		1		
winter		1		
Machine:				
Fuel				
- Litres/100km				
- Litres/hr		36.0		
- $/Litre		0.86		
Lubes - % of fuel $		8.00%		
DEF - % of fuel $		5.00%		
Repair $/yr on parts & labor		21,525	11,877	33,402
Tires				
Tires used/yr		10	20	30
$/tire		625	575	

Appendix 10. Rate model for the 8 axle jeep tridem hauling to Edson.

ASSUMPTIONS	Common to ALL	Tractor	Trailer	Total Unit
Average Distance: km				
Summer		210	210	210
Winter		210	210	210
Average Tonnes/Load				
Summer		38.18	38.18	38.18
Winter		40.33	40.33	40.33
Average Cycle Time				
Summer		4.9	4.9	4.9
Winter		4.9	4.9	4.9
Trips per Day (# of cycles)				
Summer		2.5	2.5	2.5
Winter		2.5	2.5	2.5
Available Haul Days				
Summer		135	135	135
Winter		70	70	70
		205	205	205
Fixed Costs:				
Purchase Price - $		215,250	118,769	334,019
Depreciation Life (yrs)		7	10	
Downpayment - $		43,050	23,754	66,804
Resale Value - $		43,050	14,252	57,302
Interest Rate - %	5.50%			
Insurance - % of capital	4.00%			
Overhead				
License - $	3,456			
Radio/cell - $/season	1,000			
Tire chains, ropes, etc	2,000			
Tools - $	500			
Permit costs ($)	820			
CVIP inspection - $		400	400	800
Variable Costs:				
Labor:				
Base Wage - Operator $/hr		35.00		
Overtime - Multiplier	16.6%			
Holiday Pay - %	5.0%			
WCB - %	3.0%			
EI - maximum/yr/person	$1,171			
CPP - maximum/yr/person	$2,564			
Benefits - %	0.0%			
# of operators				
summer		1		
winter		1		
Machine:				
Fuel				
- Litres/100km				
- Litres/hr		36.0		
- $/Litre		0.86		
Lubes - % of fuel $		8.00%		
DEF - % of fuel $		5.00%		
Repair $/yr on parts & labor		21,525	11,877	33,402
Tires				
Tires used/yr		10	20	30
$/tire		625	575	

Appendix 11. Rate model for the 7 axle tri-tri hauling to Drayton Valley.

ASSUMPTIONS	Common to ALL	Tractor	Trailer	Total Unit
Average Distance: km				
Summer		210	210	210
Winter		210	210	210
Average Tonnes/Load				
Summer		32.83	32.83	32.83
Winter		40.56	40.56	40.56
Average Cycle Time				
Summer		4.9	4.9	4.9
Winter		4.9	4.9	4.9
Trips per Day (# of cycles)				
Summer		2.5	2.5	2.5
Winter		2.5	2.5	2.5
Available Haul Days				
Summer		135	135	135
Winter		70	70	70
		205	205	205
Fixed Costs:				
Purchase Price - $		252,000	86,670	338,670
Depreciation Life (yrs)		7	10	
Downpayment - $		50,400	17,334	67,734
Resale Value - $		50,400	10,400	60,800
Interest Rate - %	5.50%			
Insurance - % of capital	4.00%			
Overhead				
License - $	3,456			
Radio/cell - $/season	1,000			
Tire chains, ropes, etc	2,000			
Tools - $	500			
Permit costs ($)	820			
CVIP inspection - $		400	400	800
Variable Costs:				
Labor:				
Base Wage - Operator $/hr		35.00		
Overtime - Multiplier	16.6%			
Holiday Pay - %	5.0%			
WCB - %	3.0%			
EI - maximum/yr/person	$1,171			
CPP - maximum/yr/person	$2,564			
Benefits - %	0.0%			
# of operators				
summer		1		
winter		1		
Machine:				
Fuel				
- Litres/100km				
- Litres/hr		35.0		
- $/Litre		0.86		
Lubes - % of fuel $		8.00%		
DEF - % of fuel $		5.00%		
Repair $/yr on parts & labor		25,200	8,667	33,867
Tires				
Tires used/yr		14	12	26
$/tire		625	575	

Appendix 12. Rate model for the 7 axle tri-tri hauling to Edson.

ASSUMPTIONS	Common to ALL	Tractor	Trailer	Total Unit
Average Distance: km				
Summer		210	210	210
Winter		210	210	210
Average Tonnes/Load				
Summer		39.63	39.63	39.63
Winter		41.04	41.04	41.04
Average Cycle Time				
Summer		4.9	4.9	4.9
Winter		4.9	4.9	4.9
Trips per Day (# of cycles)				
Summer		2.5	2.5	2.5
Winter		2.5	2.5	2.5
Available Haul Days				
Summer		135	135	135
Winter		70	70	70
		205	205	205
Fixed Costs:				
Purchase Price - $		252,000	86,670	338,670
Depreciation Life (yrs)		7	10	
Downpayment - $		50,400	17,334	67,734
Resale Value - $		50,400	10,400	60,800
Interest Rate - %	5.50%			
Insurance - % of capital	4.00%			
Overhead				
License - $	3,456			
Radio/cell - $/season	1,000			
Tire chains, ropes, etc	2,000			
Tools - $	500			
Permit costs ($)	820			
CVIP inspection - $		400	400	800
Variable Costs:				
Labor:				
Base Wage - Operator $/hr		35.00		
Overtime - Multiplier	16.6%			
Holiday Pay - %	5.0%			
WCB - %	3.0%			
EI - maximum/yr/person	$1,171			
CPP - maximum/yr/person	$2,564			
Benefits - %	0.0%			
# of operators				
summer		1		
winter		1		
Machine:				
Fuel				
- Litres/100km				
- Litres/hr		35.0		
- $/Litre		0.86		
Lubes - % of fuel $		8.00%		
DEF - % of fuel $		5.00%		
Repair $/yr on parts & labor		25,200	8,667	33,867
Tires				
Tires used/yr		14	12	26
$/tire		625	575	