COST EVALUATION OF AN INTEGRATED SAWLOG-PULPWOOD-FUELWOOD SITE ON BONAVISTA PENINSULA, NEWFOUNDLAND

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BY

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ABSTRACT

This evaluation involved the compiling of all pertinent cost information and the development of a model in order to forecast the annual operating cost of a proposed integrated sawlog-pulpwood-fuelwood site on Bonavista Peninsula, Newfoundland (Department of Forest Resources and Lands, Forest Management Unit 2). It is an attempt to follow a systematic approach to cost analysis of a proposed expanded forest industry in the area which involves a centralized chip processing operation. Production and transportation parameters are specified in the series of mathematical equations which comprise the model. The influence of varying wood delivery form, product selection, and transportation mode on the annual operating cost can be examined with use of the model.

The aspect of long distance product delivery to market was examined for three modes of transportation: (1) marine (2 barge - 1 tug system); (2) rail ("piggy-back" method of rail shipment) and (3) road (5-axle truck-semi-trailer combination). Within the production restraint set by the annual allowable cut which places a limit on maximum volume of wood processed, it was concluded that road transport was the most economical mode.

Potential revenue from the proposed operation is tabulated and intangible benefits expounded. This was done to view costs and benefits in perspective of one another.

The operation on a purely economic basis is not feasible under existing conditions and existing markets.

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LIST OF ABBREVIATIONS

fbm	board foot
hr.	hour
G	specific gravity
km	kilometre
MC	moisture content (based on bone dry weight)
m^3	cubic metres
Mfbm	1000 board feet
yr	year
SW	shortwood
TL	tree-length wood
ha	hectare
PMH	productive man hour
AMH	available machine hour
B/C	benefit-cost ratio

CHAPTER ONE

INTRODUCTION

The 1973 Federal-Provincial Task Force on Forestry recommended an investigation into the concept of integrated sawlog-pulpwood logging in Newfoundland.[1] The 1981 Royal Commission of Forest Management and Protection considered the concept in its study and concluded that although the idea is not widely practicable, it should not be considered an inappropriate concept.[2]

The 1981 Royal Commission recommended the harvesting of pulpwood in remote island regions, Supply Zones 2 and 3 (Figure 1), in order to alleviate the expected deterioration of Newfoundland's wood supply.[2] With or without forest protection, there is expected to be a wood shortage by 1990. Depending on the degree of forest protection available wood volume on the Island of Newfoundland will fall short of the projected requirements by 14 to 31 percent.[3]

Consideration of the growing importance of fuelwood, along with the two aforementioned harvesting concepts, has led to the possiblility of establishing an integrated sawlog-pulpwood-fuelwood logging site on Bonavista Peninsula (Figure 1).

This remote island area (Forest Management Unit 2; Supply Zone 3) will be investigated by the author as a potential area to set up a central sorting and marshalling yard because of the present need to silviculturally improve

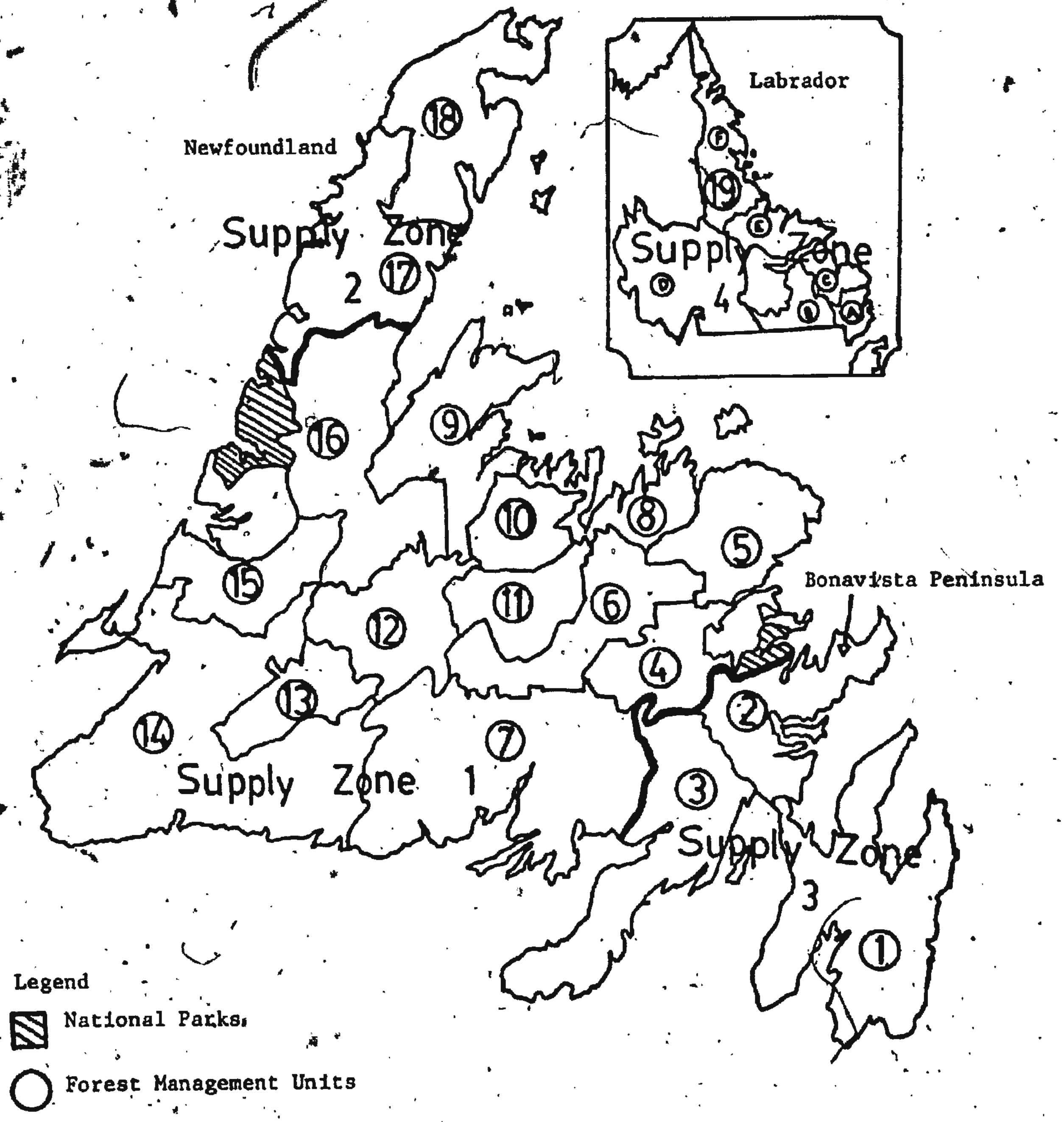

Figure 1. Forest Management Units and Timber Supply Zones.

the Bonavista Peninsula area forest stands, apply full utilization of its available resource base, and supply the required sawlogs to the unit's sawmills. Bonavista Peninsula is specifically important with regards to the sawmill industry because it is the leading lumber-producing unit in the province, with about 1/3 of Newfoundland's sawmills situated in the area.[4],[5],[6] However, implementation of this proposed integrated logging site on Bonavista Peninsula would not be an attempt to increase the productivity of the sawmills in the area, but rather be a source of supplying the dwindling number of quality sawlog-size logs.

Implementation of a clear-cutting method for multi-product wood harvesting would have silvicultural as well as economic advantages. A clear-cut, which is the cheapest and most practical harvesting method, would remove all standing timber and facilitate establishment of a silviculture improvement program for future growth. Such a harvest of poor quality stands, mixed hardwood-softwood stands, and stands of non-merchantable growth with scattered large volume stems could be economically feasible with the establishment of an integrated logging site.

A central handling and sorting site would act as a collection and brokerage point, the primary product being sawlogs, with fuelwood and pulpwood being secondary products. Use of a handling yard implies full utilization of the available resource base. Selection of sawlogs as the primary product concern would improve availability of larger size timber and improve the chance for continuity of the sawmill industry. If markets for all harvested wood could be found, logging waste would be minimized and economic activity in the wood products industry increased in the Bonavista Peninsula region.

Marketability of the fuelwood and pulpwood is greatly dependent on transportation and handling costs. Previous government analysis has indicated that delivery of pulpwood roundwood by marine mode from the Bonavista Peninsula to Grand Falls is about 18% greater than from present wood sources.[2] Therefore, the transportation aspect of an integrated logging site needs to be stressed in an economic evaluation. Costs of shipping wood from outside Supply Zone 1 restrict pulpwood production in remote areas. However, as wood supplies dwindle near mills, more distant areas may become feasible.

Presently, wood harvesting on the Bonavista Peninsula is principally carried out to supply sawlogs for the sawmill industry and local fuelwood.[5],[6] Full utilization of these forest stands would mean drastically reducing logging waste and establishing a desireable regeneration pattern with improved productivity per hectare.

An economic evaluation of an integrated logging site on Bonavista Peninsula is an essential step in the decision-making process of whether it is feasible to establish this type of expanded forest industry in the area. It is not the final step because intangible considerations as well as federal and provincial government policies are extremely influential in any future development schemes. In a systematic approach to project planning, the economic evaluation is the investigative step of interpreting pertinent cost and revenue information in relation to any known socio-economic and environmental conditions.

CHAPTER TWO

BACKGROUND INFORMATION ON FOREST MANAGEMENT UNIT 2

The Bonavista Peninsula area, designated as Forest Management Unit 2, is one of the nineteen forest management regions of the province of Newfoundland. It is situated on the East coast of the island, bound by Terra Nova National Park in the North, Pipers Hole river system and Abitibi-Price Co. holdings in the West and the Isthmus of Avalon to the South.[5],[6]

Forest Management Unit 2 is contained in the Timber Supply Zone 3. The area is not considered within current economical transport distance to the province's established pulp and paper mills. However, this distance is dynamic with changes in wood fiber values and transport cost.

The Bonavista Peninsula area is principally Crown-owned with private holdings near or in communities. Therefore, the Newfoundland government has almost exclusive management control over the region's forest stands.[5]

Approximately 37% of the Bonavista Peninsula management unit's total area (393,000 hectares) is classified as productive forest land. The remainder is shrub, barrens, bog, or cleared land.[5] Timber access problems due to steep slopes (greater than 60^{o}) is not of specific concern in the region.

2.1 Forest Industry

2.1.1 History

Early utilization of the Bonavista Peninsula's forest resource was restricted to the easily accessible stands near communities, and along rivers, ponds and the sea. The waterways not only allowed access and a transport mode, but were the source of the industry's power.[7]

The export of large white pine (Pinus strobus L.) to the British Isles for shipbuilding purposes was an integral part of the forest industry at the turn of the century. Its significance continued until overcutting depleted the stock to negligible amounts.[7]

The long term, principle demand on standing timber has been for domestic use. Construction of homes and boats stimulated the growth of the sawmill industry, while fuelwood has maintained its importance as a heat source. Sawn lumber production increased with the advancement of Newfoundland's transport system. The availability of rail, then road mode of transportation, opened marketplaces for expanded lumber production.[7]

The opening of the first Newfoundland pulp and paper mill at Black River near Swift Current in 1897 created a market for Bonavista Peninsula area pulpwood. However, the controlling firm of Harvey and Company soon went bankrupt and the mill closed. Demand for pulpwood from the Bonavista Peninsula area never became re-established despite attempts to export quantities in recent years from both Chance Harbour and Bloomfield (Figure 3). These failures have been attributed to handling and transport costs and to unfavourable market conditions.[7]

2.1.2 Present Status of the Forest Industry

The sawmill industry is the only persistent, commercial, large scale forest industry in Forest Management Unit 2. The acquisition of fuelwood from standing timber or from sawmill residue, although of continued major importance, is solely related to domestic consumption and is not classified as a commercial venture.[5],[6]

The logging method used by the sawmill operators is a selective cut (hygrading). With this practice, the largest best formed trees are harvested, leaving those unsuitable in size and shape standing. The impact of this type logging also results in a lower quality gene pool which can result in poor quality natural regeneration and in extremely high costs ($1300/ha) to clear off poor stands. Scattered selective logging has been carried out throughout the management unit, but the major hygraded stands are in areas adjacent to the forest access roads (Figure 2).

There were 517 licensed sawmills and 6 planer mills operating in the Bonavista Peninsula area in 1980,[4],[5],[6] a sawmill being one which is engaged in production of rough lumber or unfinished squares, and a planer mill, one which buys rough lumber or squares for further processing.

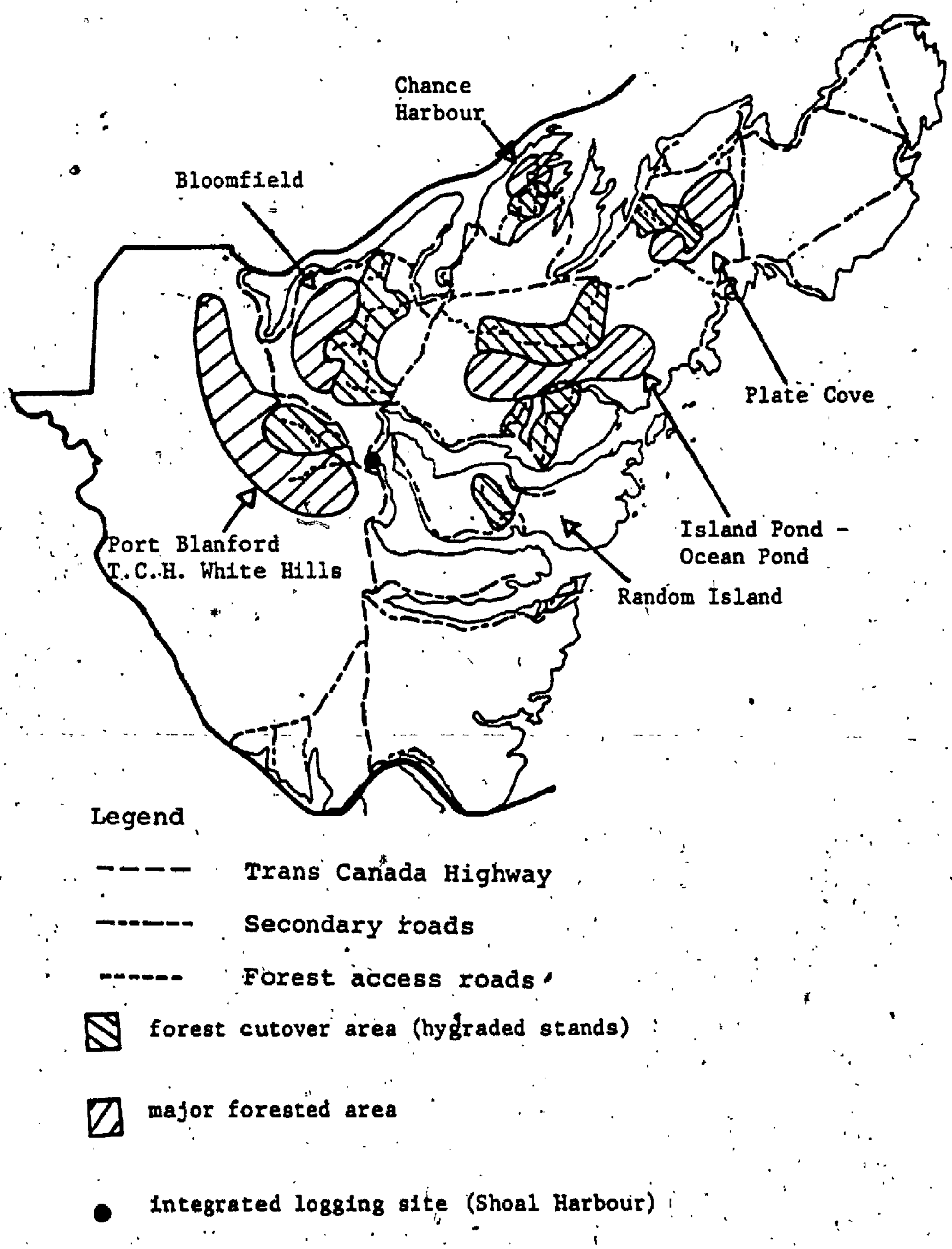

Figure 2. Wood Harvesting Areas of Forest Management Unit 2

No planer mills engage solely in purchasing rough lumber or squares. No kiln drying is done.[6]

Of the 517 sawmills, about 85% produce less than 60 m^3/yr. and account for only 30.5% of the unit's sawn lumber production. These smaller sawmills are strictly part-time operations, in business only to supplement incomes.[5],[6] Table 2.1 shows the distribution of sawmills in the area by production classes.

Table 2.1 Number of sawmills by production classes 1978-1980

Annual Production (fbm)	% of Total Mills	% of Production
0 - 25,000	84.8	30.5
25,001 - 50,000	5.5	13.5
50,001 - 100,000	5.0	23.0
100,000 +	4.7	33.0

Rough lumber, mostly in the form of squares, is sold to the planer mills. These planer mills produce dressed lumber, with the three (3) larger ones located in the Bloomfield-Jamestown area handling most of the Bonavista Peninsula ares's rough lumber.[5],[6]

The average annual production in the 1980-81 fiscal year was estimated at 42,000 m^3 or about 9 million fbm. With the annual allowable cut (AAC) for sawlogs set at 7 million fbm, this means there was an overcut of approximately 22%.[5]

2.2 Forest Resource

2.2.1 Species

The principle commercial species of Forest Management Unit 2 are balsam fir (Abies balsamea (L.) Mill.) and black spruce (Picea mariana (Mill.)B.S.P.). Their combined timber volume comprises 89% of the total forest composition, with the remaining volume being white birch (Betula papyrifera Marsh.), white spruce (Picea glauca (Moench) Voss), larch (Larix laricina (DuRoi) K. Koch), trembling aspen (Populus tremuloides Michx.), and red maple (Acer rubrum L.).[5],[7]

Primarily, black spruce is found in pure, even-aged stands, and can be traced back to growth following the forest fires of the early 1900's. This is particularly evident in the Northeast portion of the peninsula.[7]

Balsam fir is found in mixed stands with black spruce, in mixed softwood-hardwood stands, and in pure stands. When in association with black spruce, it is assumed the stand originated following fires. When in association with hardwoods or in pure stands, it is assumed to be a result of selective logging practices opening areas of previous forest cover.[7]

Table 2.2 Gross merchantable volume by species and age class[5]

Merchantable Volume by Age Class (m^3)

Species	41-80 yrs.	81+ yrs.	Total	Percent
Black Spruce	4,658,000	901,000	5,559,000	51%
Balsam Fir	2,955,000	1,128,000	4,083,000	38%
White Birch	633,000	137,000	770,000	7%
Other	319,000	70,000	389,000	4%
Total	8,565,000	2,236,000	10,801,000	

2.2.2 Stand Conditions

Age classification of the productive forest area indicates a high percentage of mature and overmature standing timber (Table 2.2). The combined age classes of balsam fir and black spruce account for 89% of the total volume. Only 8% is immature and 3% is "not sufficiently restocked" (NSR).[5],[7]

Unit 2 Forest Management Inventory indicates the productive forest area is classified as either possessing medium or poor forest capacity, with 75% of the area of medium capacity, and 25% poor.[5]

The shore of Trinity Bay, with its shallow, rocky belt of soil and the barren lands of the Bonavista-Catalina area which are a result of repeated burns are non productive. As well, the barrens of Central Newfoundland which extend into the Bonavista Peninsula region West of the Shoal Harbour River Valley and the shrub forest in the area of high elevation just North of Sunnyside and Come-By-Chance has limited tree growth. The major productive forest lands are in the West and central portions of the the Bonavista Peninsula region (Figure 2).[7]

The spruce budworm (Choristomeura fumiferana Clemens) has caused considerable damage to the Bonavista Peninsula balsam fir stands since it spread into the area in 1975-76. However, the spruce forest stands have seemingly escaped similar devastation.[5]

2.2.3 Annual Allowable Cut (AAC)

The estimated annual allowable cut is calculated by the Newfoundland Department of Forest Resources and Lands based on the area allotment method with a volume check. The area allotment method is one in which aerial photographs are used to delineate homogeneous areas of forest types as well as to define forest stands. The area of the stands are measured and in conjunction with stand volume tables, an estimate of gross wood volume is obtained. A volume check entails field measurements of representative forest stand plots in order to verify or make allowances in the stand volume tables.

Net AAC allows for reductions due to steep slopes, isolated stands, logging loss and cull, and considers only productive forest land in its calculation. Forest Management Unit 2 has a net AAC of 164,000 m^3. This includes an area overcut of 40% for a 40 year planning period in order to reduce overmature stands to achieve a more uniform age distribution. Therefore, by the end of the 40 year planning period, the AAC will have to be adjusted.[5]

An estimated 20% of the merchantable volume is sawlog size. Assuming this percentage is directly transferable to a sawlog AAC, 33,000 m^3 (7,000,000 fbm) becomes the estimated AAC for the sawmill industry.[5]

Recent Newfoundland fuelwood studies have approximated the Unit 2 domestic consumption at 45,783 m^3.[8] However, it was emphasized that many households burned slabs and edges supplied from the numerous local sawmills. A study also pointed out that the fuelwood harvest might not be exclusively done on productive forest land, so there may not be such a significant drain on the net AAC as the data indicates.[6],[8] However, the figure of 46,000 m^3 will be used as a conservative estimate of domestic fuelwood consumption.

Combining fuelwood consumption and sawlog AAC (28% and 20% respectively), the remainder of the net AAC, or about 85,000 m^3 (52%), is available for future forest products industry expansion.

2.3 Transportation Network

The presence of highways, railways, and marine transport facilities in Forest Management Unit 2 (Figure 3), means that a potential versatility exists in selection of modal choice for product delivery. Therefore, several transportation options can be examined with respect to characteristics of goods transferred.

The main artery of the road transport network in the Bonavista Peninsula area is the Trans Canada Highway (Route 1). There are several connecting routes from the peninsula communities to the Trans Canada Highway, and forest access roads feeding into these connecting routes, as well as into the Trans Canada Highway.

The Canadian National Railway runs parallel to the Trans Canada Highway. There is also a branch line running from the community of Bonavista to Clarenville, parallel to Route 230. However, this branch line is in relatively poor condition and has a half-load capacity restriction imposed on it.

Marine facilities of varying size and capacity exist all along the coastline. However, any large scale transfer of goods by ocean going vessels would require docks or wharfs of suitable capacity and sturdiness.

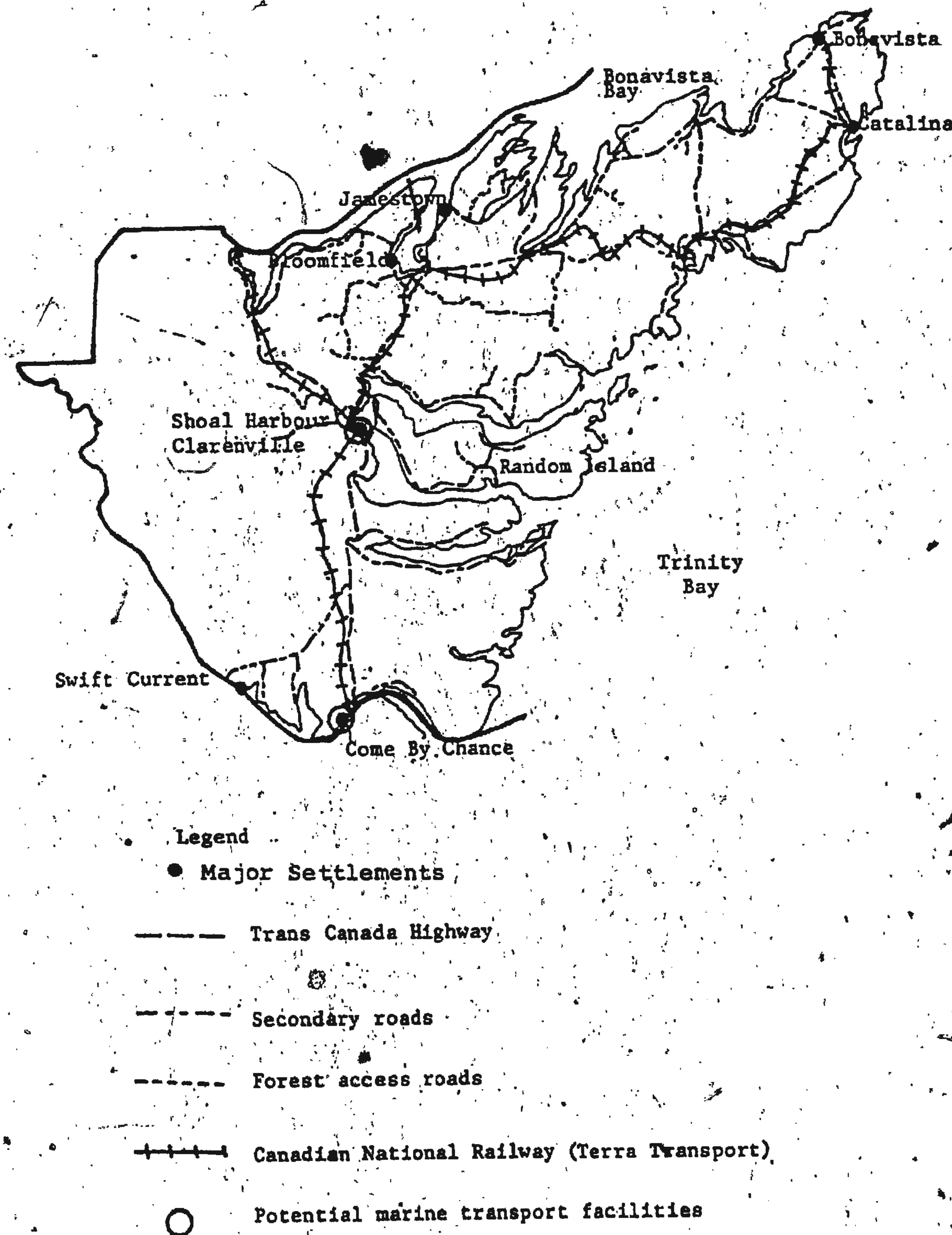

Figure 3. Bonavista Peninsula Transportation Network.

CHAPTER THREE

INTEGRATED LOGGING PROPOSAL

3.1 Problem Statement

Utilization of the available forest resources in Forest Management Unit 2 is poor. The area is at a competitive disadvantage in finding a market for pulpwood because of high transportation costs. Therefore, the forest industry has revolved around the production of lumber. This concentration of manpower and investment in a single aspect of the industry has led to a diminished supply of sawlogs and left forest stands of genetically inferior quality which have often been severely damaged during selective logging. As expressed by Grant Milne in his Bonavista Peninsula study:

> "The industry exhibits the classic signs of an over-exploited common property resource sector with declining average incomes, increasing scarcity of easily accessible resources and increasing entry of firms over time".[6]

Even the nature of the sawmilling industry tends to lead to wastage, with wood residue from saw kerf, slabs and edges often comprising 50% of the sawlog component of the log.

The problem this cost evaluation will address is the under-utilization of the forest resource base of Forest Management Unit 2 with consideration of environmental and socio-economic implications of the limited use of this resource sector.

3.2 Objectives

The economic evaluation of an integrated sawlog-pulpwood-fuelwood logging site on the Bonavista Peninsula is an attempt to:

- estimate costs which would result from harvesting, handling, sorting, and processing at a central yard, and transporting sawlogs, pulpwood chips and fuelwood chips to market;
- to develop a costing model to analyze an expanded and versatile multi-product forest industry in the area; and
- analyze choice of mode or modes of transportation for product delivery to market based on sensitivity to productivity of the the integrated operation.

The multi-product centralized approach of integrated logging should mean improved management of the available forest resources. With more potential forest products, harvesting will no longer be limited to the best formed large trees required for the sawmill industry. This will result in more complete utilization of the available forest resources, decrease logging waste and clear land for preparation for improved silviculture.

Versatility in the integrated logging scheme is a desirable socio-economic aspect of the operation. By manipulating product selection with regards to fuelwood and pulpwood according to market conditions, there is an increased chance for a continuous, high volume operation.

The intent of this analysis is not to propose an alternative to the status quo that would drastically alter the present status of the sawmilling industry or consumption of fuelwood for domestic use in the Bonavista Peninsula area, but to examine an expansion of the present forest industry as a whole.

3.3 Method of Evaluation

Accumulation of cost information for the harvesting, the marshalling yard operation and the transportation of products to market receiving points is required. Costs will include purchasing and handling of the tree length and shortwood delivered to the site, sorting, processing required for each product, handling within the yard and shipping to markets. These cost estimates will be amassed from previous federal and provincial studies and reports by consultants under contract to them, as well as from recommendations supplied to private industries directly involved with specific aspects of the proposed integrated logging scheme.

Cost components for each phase of the operation and forest product choice will be estimated with as much accuracy as possible in order to develop a series of mathematical equations which would generate an aggregate annual cost value dependent on annual production and raw material supply characteristics, as well as reflect the effect of the product transport mode.

The costing model will determine an annual operating cost of the total operation opposed to "per unit" costs because of the difficulty in assigning values on a product-component basis, as it was realized in a previous Newfoundland integrated logging trial.[9]

Output units of the model will be measured in terms of the 1982 Canadian Dollar. The model will consist of three parts, which will correspond to the three phases of the integrated logging operation:

1. Extraction from stump and transport to the site;
2. Processing and handling at the site;
3. Transportation and handling from site to market.

Input and output volumes or weights used in the model equations will be expressed in the accepted forest measurement unit (Appendix A) with regards to convention for wood fiber form (Table 3.1).

Table 3.1 Wood measurement units

form of wood fibre	measurement unit
roundwood (TL or SW)	m^3 (volume)
sawmill residue	green tonne (weight)
sawlogs	Mfbm (volume)
chips	green tonne (weight)
* pulpwood chips specifically	bone dry tonne (weight)

To view cost values in perspective, potential revenue for production will be indicated at 1982 prices. Therefore, annual cost and generation of revenue estimates over a range of production and transportation characteristics should give insight into possible decisions regarding optimum situations.

* Pulpwood chips are purchased on the basis of bone dry weight, so when pulpwood chips are specified in the model, bone dry tonne will be the measurement unit used.

3.4 Integrated Logging Site Description

An integrated sawlog-pulpwood-fuelwood logging site would act as a marshalling yard which would receive tree length or shortwood logs, as well as slabs, edges, and sawdust from local sawmills. The site would be used for storage, processing and administration. Purchased wood, either hardwood or softwood would be scaled on delivery. Hardwoods would be stockpiled separate from the softwoods, and then chipped for fuelwood. Sawlog lengths would be slashed from the softwood which is of acceptable size. Some softwood would be debarked and chipped for pulpwood. These chips would be kept separate from the fuelwood chips. Administration would keep track of inventory levels, as well as keep the accounts for the many aspects of the operation.

3.4.1 Location

Location of the logging site is of major importance to the proposal. It should be centrally located to the productive forest areas of the Bonavista Peninsula with access to all appropriate modes of transportation. Availability of suitable land is also necessary.

The Bloomfield-Jamestown area of Bonavista Peninsula is centrally located. However, there is no suitable transportation access. No suitable marine docking facilities exist in this area. The Railway is restricted to half-load capacity on the branch line to Clarenville. Road transport from this area would mean an additional distance of about 40 km on secondary roads to be travelled when hauling chips to market.

The Bonavista-Catalina area is neither centrally located; nor has suitable access to the transport modes.

Swift Current and Come-By-Chance areas are located outside the productive forest regions of Bonavista Peninsula. An integrated logging site established in these areas would mean increased transport distance both to and from the site.

Clarenville would appear to be the most acceptable location in which to establish an integrated logging site if proximity and access to transportation are considered. Unfortuneately, there is no land available adjacent to the community for such an industry.

The area around the community of Shoal Harbour known as "Gravel Hill" appears to fit all requirements. Not only does the settlement have suitable access to road, rail and sea, it is situated fairly central to the productive forest area. The Trans Canada Highway is about 5 km away, the Clarenville CN rail station about 3 km away, the Newfoundland Hardwoods wharf - where there is potential for sharing marine facilities - about 3 km away. Of course, an integrated logging site near Shoal Harbour would require the community council's approval.

3.4.2 Capacity

The logging site would handle a maximum of 93,000 m^3 of wood annually. This would consist of 85,000 m^3 of the remaining net AAC for Forest Management Unit 2 and 8,000 m^3 of sawmill residue (approximately 25% of the 33,000 m^3 of the sawmill AAC). Of course, market supply and demand could limit utilization of the facilities which could result in non-mechanical equipment downtime and high level inventories or shortages of products.

3.4.3 Harvesting and Transport to Site

All harvesting operations will be manual cut and skid. The manual cut and skid logging method is labour intensive, requires low capital investment, has low cost maintenance requirements, and is versatile with regards to ground bearing capacity and ground roughness conditions encountered during harvesting. A mechanized operation is an appropriate concept to consider when there is a shortage of labour and well-stocked forest stands. It requires relatively high capital investment with the anticipation of high cost maintenance. Since there is no shortage of manpower in the Bonavista Peninsula area, nor well-stocked forest stands; it would indicate that a manual cut and skid operation is the desireable one, especially with the economic advantage of requiring a lower capital outlay of monies than the mechanized operation.

The cost of roundwood delivery from the stump to the integrated logging site will vary according to whether shortwood or tree-length wood is being transported.

The shortwood could be purchased at the site with the cost of harvesting and transportation to be borne by the sellers who would be small-time logging contractors. The purchase of tree-length wood from these contractors will not be considered. Although tree-length timber extraction requires less handling because it involves less stems per volume, it does require mechanical loading. Shortwood can be handled manually. Since investment in loading equipment is not attractive to these contractors because of the scattered distribution of standing timber which makes a large scale logging operation unsuitable, shortwood is their only option.

Tree-length timber extraction would be carried out by operators under the administration of the integrated logging site. This is to ensure that a reliable supply of timber is available.

The conventional mode of transporting tree-length wood by self-loading truck and semi-trailer units will be used. A short haul on existing secondary highways and forest access roads more or less dictates this solution.

Sawmill residue will be delivered to the Shoal Harbour site by whichever means of transport available to the sawmill operators. Residue will include slabs, edges and sawdust; but it is expected that sawdust will be the major form of sawmill waste since slabs and edges are consumed locally as fuelwood.[8]

3.4.4 Processing

At the integrated logging site, wood will be unloaded, scaled and sorted. Sawlogs will be manually slashed from suitable sized tree-length stems. The expected relatively low sawlog production volume does not warrant mechanical slashing. All hardwoods will be chipped for fuelwood since hardwood chips are not acceptable to Newfoundland's pulp and paper mills. Some softwoods would also be chipped for fuelwood, depending on fuelwood and pulpwood market potential. Chipping will be done with a self-feeding portable chipper which blows the chips directly into waiting chip vans.

Softwood to be utilized as pulpwood must first be debarked and then chipped because of the chip quality requirements demanded at the pulp mill. Naturally, any storage or stockpiling of chips would require separate holding facilities.

Sawmill residue is accepted at the processing and handling area as potential fuelwood. Any slabs and edges would be chipped along with other fuelwood.

One of the major considerations in establishing the integrated logging site is the versatility of the operation as a whole. However, minimal capital investment is also of importance in relation to the expectation of marginal profit from the operation. Conflict between these decision-making criteria means priorities must be balanced. This is reflected in the decision to produce both pulpwood and fuelwood chips and in the selection of equipment and establishment of manpower requirements. Equipment and manpower requirements were determined by consulting

Newfoundland provincial government engineers, reviewing publications concerned with chipping operations, and checking specifications and details of production capacities of available and appropriate equipment.[12],[13],[14],[15] Equipment and manpower requirements are presented in Table 3.2 and 3.3 respectively.

Table 3.2 Equipment required for processing

front end loader (used)
debarker
infeed deck (for debarker)
chipper
chip storage facilities

Table 3.3 Manpower required for processing*

management (3)
foreman
scaler
office clerk
maintenance personnel (1)
equipment operators (4)
debarker operator (2)
front end loader operator
chipper operator
labourer (1)

* These are requirements for low capacity production. More heavy equipment operators and additional labourers would be required if production increased to a point where this was warranted.

3.4.5 Handling and Transport to Market

The short haul of sawlogs to local Bonavista Peninsula area sawmills will be restricted to truck transport. Again, self-loading truck semi-trailer units will be used for intra-management unit transport.

Chip movement has potentially three modes of transportation which can be utilized. Depending on which mode is chosen, storage capacity and facility requirements will vary. With road and rail (piggy-back) transport, chips would be blown directly into waiting chip vans at all times. There would always be an appropriate number of spare chip vans to hold potential production when previous production is in transit. This means there is control of handling and storage. Stockpiling is required for the marine mode since there is no handling advantage in the use of chip van storage.

For road transport of chips, there would be no transfer of chips until arrival at the Abitibi-Price Mill in Grand Falls (chip market), and this ease in handling is reflected as an economic advantage. Likewise, availability and efficiency of this mode means shorter round-trip times and little scheduling difficulties.

Using the "piggy-back" method of rail transport would eliminate the problem developed by lack of specialized chip rail cars. Standard length 40-foot vans would have to be trucked to the Clarenville CN rail station to be loaded onto rail flat cars. Like road transport, there is no direct handling of chips until vans reached the mill, but the van itself must be transferred twice. Rail mode of transport is suitable for regular, high capacity hauls over long distances.

The marine mode of transport for chips requires that the chips be transferred from the site to dockside, as well as form the receiving dockside terminal to market. Utilization of a barge-tug system would be suitable because of the homogeneous nature of wood chips (despite having two types of wood chips - pulpwood chips and fuelwood chips). However, to be economically feasible, production must be sufficiently high and the transfer of chips on and off the barge properly and efficiently handled.

CHAPTER FOUR

ECONOMIC EVALUATION

4.1 Costing Model Development

Harvesting and delivery aspects of the economic evaluation which are considered to contribute significantly to the wood procurement costs of the operation are explained during the first part of the model development. Explanation of the processing situation and how the annual costs are determined for this phase are stated in the second part. In the third part, the three transport modes of marine, rail, and road, as well as the handling and storage requirements for each, is examined.

Three cost equations are developed to indicate component costs of the three phases of the operation. Each component cost is dependent on a number of variables. The relationship between the component costs and the variables is explained in later parts of this chapter. The first cost equation is the cost of wood procurement, C(1); the second is the cost of processing, C(2); and the third is the cost of product transportation to market, C(3). The summation of these three cost equations indicates the total annual operating cost of the integrated logging site.

Wood procurement costs include felling, skidding, handling and transportation to the integrated logging site (Table 4.1). The cost components of this phase are related to the amount of shortwood, tree-length and residue delivered to the site. The volume of each timber form and the weight of residue delivered are the variables for cost equation C(1).

Table 4.1 Wood Procurement Costs

Tree-length Procurement
- fell
- skid
- sort
- loading onto truck semi-trailor
- line haul (road)
- off-loading

Shortwood Procurement
- purchase from contractors

Residue Procurement
- purchase from sawmill operators

Road Maintenance

Stumpage Fees

The second cost equation deals with the processing of the wood (Table 4.2). The variables for the equation are the capital recovery factor (CRF), and the amount of pulpwood chips and fuelwood chips produced.

Processing includes handling at the site, debarking pulpwood roundwood, chipping of all pulpwood and fuelwood with separate storage of each chip product. Sort and manual slashing of sawlogs is also part of processing.

Table 4.2 Processing Costs

Fixed Cost

capital cost of building and machinery

leasing cost of land

labour cost (fixed during short term)

management
maintenance personnel
labourer
machine operators

Variable Cost

sawlog variable cost
labour (in excess of fixed labour cost)

pulpwood chip variable cost
labour (in excess of fixed labour cost)
lubricants for debarker
repair parts of debarker
service for debarker

chip (pulpwood and fuelwood) variable cost
labour (in excess of fixed labour cost)
fuel for chipper
lubricant for chipper
repair parts for chipper
service for chipper

The third cost equation of the operation determines the cost of handling and transportation to markets (Table 4.3). The variables for this equation are the amount of each product produced and the transport mode selected.

Transportation to market includes sawlog and chip delivery. Sawlog transport costs include loading onto straight trucks, delivery to area sawmill-planer mill complexes in the Jamestown-Bloomfield area, and unloading. Chip transportation includes storage, handling, and transport; depending on mode of transport. Chip unloading is carried out by the purchaser. This is reflected in the price they pay for their chips.

Table 4.3 Transportation to Market Costs

Sawlog Delivery
- loading
- line haul (truck) to Jamestown-Bloomfield area
- unloading

Chip Delivery
- storage

Road	Rail	Marine
line haul (truck vans) to Grand Falls	line haul by road to Clarenville line haul by rail to Grand Falls (piggy-back)	line haul by road to Clarenville off load line haul by tug-barge to Botwood load onto trucks line haul by truck to Grand Falls

4.1.1. Cost of Wood Delivery form Area of Origin to Integrated Logging Site

Harvesting and delivery cost of wood to the integrated logging site will consider the cost of felling, skidding, loading, road transport, and unloading. Transport cost will be based on the short haul, poor road supposition. Therefore, the cost will be based on time rather than distance. Road maintenance cost and stumpage fees will also contribute to the overall cost of procurement.

Annual harvest of standing trees will be in the form of tree-length or shortwood lengths. Shortwood and tree-length costs are estimated separately. An estimate of purchase price is determined for shortwood. For tree-length, each cost component is estimated separately.

Shortwood would be delivered to the integrated logging site by small-scale contractors working in the area. The extraction, transportation, and handling costs will be incorporated in the purchase price. The price is based on a 1980 "discussed" purchase price of shortwood from the Bonavista Peninsula region, between potential area contractors and consultants enlisted by the Newfoundland Department of Forest Resources and Lands.[13] The 1982 price is estimated by escalating the 1980 value at 12% for 2 years.

purchase price of shortwood (SW)

= (1980 negotiated purchase price)(inflation adjustment)

= $[18.70/m^3][1.254] = \$23.45/m^3$

Costs specific to shortwood (SW) procurement and delivery:

delivered purchase price $\$23.45/m^3$

Tree-length wood would be felled, skidded, and placed on roadside skidways where it will be scaled prior to further transport. This follows the conventional method of harvesting tree-length timber. It will be loaded onto self-loading truck-semi-trailer units at roadside. The truck driver will also be the loader operator so the cost of loading will be included in the truck and driver wage.

Cutting, skidding and loading are the three cost components of tree-length harvesting. The cutting cost estimate is primarily labour wages. Skidding cost involves the cost of the skidder, operating expenses for the skidder; as well as the operator's labour wage. Depreciation, interest, and insurance are fixed costs. They are incorporated into the skidding unit cost on the basis of expected productivity per productive man hour (PMH) of 10.5 m^3/PMH over a productive machine life of 8000 hrs. Variable skidder costs include repair, preventive maintenance, lubricants and fuel as well as the machine operator cost per available machine hour (AMH). The summation of these variable costs and translated fixed costs determine the unit cost of skidding tree-length. Fuel cost for the skidder is 5%; repair cost is 20%; and operator wage is 40%.

Sorting of the tree-length wood into softwood and hardwood is done at the roadside when the wood is being placed on the skidways. The skidder operator sorts at the stump and piles the wood of softwood and hardwood separately at roadside. No extra equipment is involved, however additional skidding turn-around time is probable.

Tree-length wood will be placed on roadside skidways where it will be scaled prior to further transport. It will be loaded onto self-loading truck-semi-trailer units at roadside. The truck driver will also be the loader-operator so the cost of loading will be included in the truck and driver wage. Five axle truck and loader costs are based on an available life of 18,000 hrs. Component truck costs include depreciation, interest, insurance, licensing, repair, service, lubricants and fuel. The fuel cost is about 30% of the total truck and driver wage unit cost; operator cost is 36%; repair cost is 12%.

Truck capacity for this wood transport is based on maximum allowable gross vehicle weight for a 5 axle truck-semi-trailer unit of 35,000 kg (82,000 lbs)[10], loader weight of 13,600 kg, and wood weight based on an average moisture content (MC) of 45% (Appendix A).

The major forested areas of Unit 2 are all within a 60 km radius of the integrated logging site. The estimated distances range from 30 km to 60 km (Table 4.4) If it is assumed that equal volume of tree-length wood is to be harvested from each of the six major forested areas, then the "weighted" average transport distance would be 44 km. However, if in actuality all wood came from the furthermost zone, Plate Cove, which would be the extreme situation, the maximum influence on the overall cost of tree-length delivery from stump to site would be 3%. In relation to the knowledge of the accuracy of other estimates in the model, it would be acceptable to assume a 44 km distance from stump to site for all tree-length wood.

Table 4.4 Distance from major forest areas of Management Unit 2 to Shoal Harbour

Major forested areas in Management Unit 2	Distance to Shoal Harbour (km)
Plate Cove	60
Chance Harbour	50
Bloomfield	40
Port Blanford-TCH White Hills	30
Random Island	35
Island Pond-Ocean Pond	50

Procurement cost for tree-length wood is the combined cost of harvesting and transportation to the site. Harvesting cost includes felling, skidding, and sorting. Felling is estimated to be $9.80/m^3. Skidding with a sort is estimated to be $8.20/m^3 These costs are determined by using information supplied by the Canadian Department of the Environment, Forest Research Centre of St. John's Newfoundland. Their historical records indicate this to be reasonably accurate. The handling and delivery cost is a calculated value based on the wage rate for truck and driver/operator, the round-trip time from the major forested areas of Management Unit 2 to the integrated logging site in Shoal Harbour, and the truck capacity of a 5-axle truck and semi-trailer unit equipped with a loader (Appendix B).

Current truck and driver/operator wage rate is based on a consultant report commissioned by the Newfoundland Department of Forest Resources and Lands [12], then altered to allow for the inflation (12%, for 2 yr. period). Fuel labour, and repair costs are the primary factors in determining trucking costs. Table 4.5 shows the percentage contribution of each factor to the truck and driver wage rates.

Table 4.5 Approximate % contribution of primary factors to truck and driver wage rates.

	repair	fuel	labor
3-axle straight truck	26	22	43
5-axle truck semi-trailer combination	12	30	36

Round trip time is calculated using the average distance (44 km) between the major forested areas of the Bonavista Peninsula and Shoal Harbour, the average speed of 40 km/hr which was deduced following consultation with residents of the Bonavista area, and the loading and unloading times of 0.3 hr arrived at through personal experience as an equipment operator.

round trip time (t)

$$t = 2\ \frac{\text{average distance}}{\text{average speed}} + \underset{\text{time}}{\text{loading}} + \underset{\text{time}}{\text{unloading}}$$

$$= 2\ \frac{44\ \text{km}}{40\ \text{km/hr}} + 0.3\ \text{hr} + 0.3\ \text{hr} = 2.8\ \text{hr}$$

truck loading and delivery cost (d)

$$d = \frac{(\text{truck \& driver/operator wage rate})(\text{round-trip time})}{\text{truck capacity}}$$

$$= \frac{(\$43./\text{hr})(2.8\ \text{hr})}{45\text{m}^3} = \$2.68/\text{m}^3$$

Costs specific to tree length (TL) wood procurement and delivery:

felling	$9.80/$m^3$
skidding and sorting	$8.20/$m^3$
loading and delivery	$2.68/$m^3$
	20.68m^3$

Additional costs for the delivery of wood from stump to site are road maintenance costs and stumpage fees. The road maintenance cost is an estimate from the Newfoundland Department of Forest Resources and Lands. These maintenance costs, apply to forest access roads. Future road maintenance is dependent on labour wages and equipment investment. The stumpage fee is set by Newfoundland government policy.[1] Road construction costs for future access roads will be borne by the provincial government, as is the case now.

Additional costs for harvesting of standing trees:

road maintenance cost $0.85/m^3$

stumpage fees $\underline{\$1.25/m^3}$

$2.10/m^3$

Residue would be purchased from sawmill operators at the integrated logging site. Therefore, the cost of transporting the sawdust, slabs and edges is part of the purchase price. Residue unloading costs will be absorbed as part of the cost for site processing. The price paid for the sawmill residue is an arbitrarily chosen value which is meant to reflect the market situation for this forest industry by-product. This choice of purchasing price is meant to imply marginal revenue to the sawmill operators. Although residue transportation can be done whichever way is desireable by the operator ie. in a pick-up truck, dump truck, 3-axle straight truck; the price of $5/tonne is based on loading a 3-axle straight truck and transporting the residue a distance of 60 km (maximum distance from a sawmill to the integrated logging site).

Disposal of sawmill waste, especially sawdust, is often a problem for the sawmill operators. The processing site will act as a kind of sawdust dump. Although slabs and edges are acceptable at the site as sawmill residue, it is suspected that their use as domestic fuelwood and the low price offered for the residue will deter their sale.

Costs specific to sawmill residue procurement:

delivered purchase price $5.00/green tonne

The model equation C(1) is developed by summing unit costs specific to each wood delivery form.

$$C(1) = 22.78\ TL + 25.55\ SW + 5.00R$$

where TL = tree-length wood volume (m^3)

SW = shortwood volume (m^3)

R = sawmill residue (green tonnes)

4.1.2 Cost of Processing at the Integrated Logging Site

Processing cost will consider capital investment costs, annual fixed costs, and annual variable costs attributed to the various products being processed. Sawlog variable cost will consider labourer's wage rate; pulpwood variable cost, debarker and chipper operation conditions; and fuelwood variable cost, chipper operation conditions.

Fixed Costs:

Capital investment costs will include the purchasing costs of processing and yard handling equipment, as well as office facilities (Table 4.6).

Table 4.6 Capital investment costs for integrated logging site

buildings	$ 30,000
front end loader (used)	30,000
debarkers (2 @ $60,000)	120,000
chipper	160,000
	$ 340,000

The minimum requirement for equipment deals with acceptable equipment to process all products of the operation. Two debarkers are chosen as a minimum because of the price differential between fuelwood chips and pulpwood chips (with pulpwood chips worth about 2 1/2 times more than fuelwood chips); and because of the greater quantity of softwood than hardwood (with about 92% of species volume softwood and the remainder hardwood). Also, two debarkers and one chipper would handle the maximum amount of AAC available to the integrated logging site. The chipper and debarker would have to be utilized for an additional shift if an increased level of production warranted it.

The front end loader would be used for "odd jobs", handling tree-length and shortwood around the marshalling yard, and transferring wood onto the debarker infeed deck and within reach of the chipper's loader.

Capital investment cost reflect start-up costs for processing at the integrated logging operation. The capital recovery factor (CRF) translates these capital investment costs into future annuity payments at known interest rates and known number of payments. Equipment life and salvage value are factors to consider when determining these annual costs.

The building cost is an estimate accepted, following consultation with Newfoundland government personnel. The used front end loader cost is based on a previous Newfoundland Department of Forest Resources and Lands report.[12] New equipment costs are taken from the 1982 Morbark catalog.[14]

Annual fixed costs include lease for the land, management personnel (3), maintenance personnel (1), machine operators (4), and a labourer (1) (Table 4.7). Management personnel include a scaler, a clerk and a production foreman. Machine operators are for the two debarkers, the front end loader and the chipper.

Table 4.7 Annual fixed costs for integrated logging site

lease	$ 12,000
management personnel (3)	53,000
maintenance personnel (1)	18,000
machine operators (4)	64,000
labourer (1)	12,000
building utilities, supplies, etc.	3,000
	$ 162,000

Note: Although the operation is expected to be of 200-day duration which is approximately 10 months, a lease for $1,000 per month would be paid for the whole 12 months to ensure continuity of the operation the following year.

Personnel costs are fixed because in the short term these people are required no matter what the level of productivity, as long as the site is operational. In the long term they would be variable costs when a production level is reached. Of course, if such a level is established, all fixed costs could be stated in a unit cost.

Machine operators are fixed costs because every machine must have an operator regardless of production level. Processing is meant to be a continuous "line" production where a stop at one step would interrupt the production flow. Such a stop would occur if an operator of one machine was expected to change to another in order to continue the process, even supposing all operators had the necessary skill to operate all equipment.

Scaler and other management personnel would not be allowed to take over an operator's job if the production level was low. A scaler has a specialized job and can not take over any other management position. Unions would not appreciate management doing operators jobs just because productivity was low.

Annual fixed cost estimates (lease, utilities and labour costs) were obtained from conducting exploratory discussions with members of the Newfoundland Department of Forest Resources and Lands.

Variable Costs:

Annual variable cost is chiefly dependent on fuel and maintenance requirements for the processing and handling equipment; as well as additional labour if production increases beyond the minimum level set for each product. These minimum levels are discussed later in this chapter for each specific product choice. Percentage contribution of various factors to the variable machine costs are shown in Table 4.8.

Table 4.8 Approximate % contribution of primary factors to variable processing equipment and labour costs

	% contribution to variable costs		
	repair	fuel	labour
loader	50	13	32
debarker	53	--	37
chipper	43	17	35

Annual sawlog variable cost:

Variable labour cost is based on the premise that only one half of the "mandatory" labourer's time is taken up by sawlog selection. Thus, his estimated production in that time would be used as the limit at which costs would start to escalate on the basis of sawlog production. The annual volume of wood slashed for sawlogs by him is estimated to be 800 Mfbm. This is determined by using an hourly production rate of 1.0 Mfbm which is a value chosen on a basis of personal experience.

Sawlog variable:

rate of slashing and selection of logs = 1.0 Mfbm/hr.

annual production of "mandatory" labour =

1/2 (1.0 Mfbm/hr)(8 hr/day)(200 days/yr) = 800 Mfbm

However, it is doubtful that the integrated logging site will be producing more than 800 Mfbm (approxomately 12% of the AAC for expanded industry) because of previous selective logging practices in the Management Unit 2's forest stands. Therefore, even though an annual sawlog variable cost was considered, it is not considered significant enough to be included in the costing model.

Annual pulpwood variable cost:

Variable costs attributed to pulpwood production are for repair, lubricants, maintenance of the debarkers and infeed decks, as well as additional labour charges for second debarker shifts if the market demand for pulpwood chips warrants it. It is assumed that increased usage of the debarkers and decks will not result in an increased proportion of the maintenance cost variable.

Values necessary for estimating the variable cost and production capacity are taken from a 1980 Newfoundland government report (12). Maintenance costs were escalated 12% for two years.

Pulpwood variable cost:

debarker maintenance cost

$$= \frac{(\$2.20/\text{cord})(0.415\ \text{cord/m}^3)\ (1.254)}{0.36\ \text{bone dry tonnes/m}^3}$$

= \$3.22/bone dry tonne

additional labour cost for debarker second shift when pulpwood chip demand exceeds 17,200 bone dry tonnes/yr:

debarker production capacity = 120 m^3/day = 15 m^3/hr

bone dry chip yield/hr

= ($15m^3$/hr)(0.36 bone dry tonnes/m^3)

= 5.4 bone dry tonnes/hr

operator hourly wage rate - \$11.25

labour cost for pulpwood chip production in excess of 17,200 bone dry tonnes annually

$$= \frac{\$11.25}{5.4\ \text{bone dry tonnes/hr}} = \$2.08/\text{bone dry tonne}$$

It is expected annual pulpwood chip demand will exceed 17,200 bone dry chip annually (48,000 m^3/yr). Therefore, pulpwood variable cost will consider additional labour charges, as well as debarker maintenance cost. Because pulpwood variable cost is associated with production exceeding 17,200 bone dry tonnes annually, the amount 35,800 (which is 17,200 tonnes X $2.08/tonne) is subtracted from the following equation.

Pulpwood variable cost = 3.22P + 2.08 (P-17,200)

= 5.30P - 35,800

where P = annual pulpwood chip production (bone dry tonnes)

Annual chip (pulpwood and fuelwood) variable cost:

Chipper fuel and maintenance costs are related to the amount of chips produced. It is considered that these costs will increase directly with the increase in chip production. The proportionality constant was established from examining previous chipping studies carried out under Canadian Federal government supervision [9],[15] and another study conducted with Newfoundland Provincial government assistance (unpublished).

Chip (pulpwood and fuelwood) variable cost:

chipper fuel and maintenance cost = $1.25/green tonne

Chip variable cost = 1.25Q

where Q = annual chip production (green tonnes)

The model equation expressing the annual cost of processing at the proposed integrated logging site is a summation of the three variable (CRF, P, Q) and a constant.

C(2) = 340,000 CRF + 5.30P + 1.25Q + 126,200

However, Q = 1.45 + F

where F = annual fuelwood chip production (green tonnes)

Therefore, $C(2) = 340{,}000\ CRF + 7.11P + 1.25F + 126{,}200$

where CRF = Capital recovery factor

P = annual pulpwood chip production (bone dry tonnes).

F = annual fuelwood chip production (green tonnes)

4.1.3 Cost of Wood Delivery from the Integrated Logging Site to Market

Cost of wood delivery to market will depend on storage, handling, transfer and transport requirements for the three modes of transportation: roadway, rail, and marine. Some costs will be taken as fixed costs and some as variable with respect to production output.

Transport rates will vary with mode of transportation utilized. Sawlogs will most likely find a market in the Bloomfield-Jamestown area where three of the six management unit's sawmill-planer mill complexes are located. Since the haul is a short one, only truck transport will be considered as a mode of transportation. Likewise, a short haul over secondary roads means an hourly rate will be used for truck and driver in the cost analysis. Sawlog delivery cost is established similar to the calculation of tree-length delivery cost to the integrated logging site. Only the average distance, loading and unloading times are altered to reflect the difference in situations. The haul distance is 30 km. Loading and unloading times for shortwood are considered longer than times for handling tree-length wood.

Cost of sawlog delivery:

truck capacity = 9.54 Mfbm

round-trip time

$$= 2\ \frac{\text{average distance}}{\text{average speed}} + \text{loading time} + \text{unloading time}$$

$$= 2\ \frac{30\text{km}}{40\text{km/hr.}} + 0.5 + 0.5 = 2.5 \text{ hr.}$$

truck loading and delivery cost (d)

$$d = \frac{(\text{truck \& driver/operator wage rate})(\text{round-trip time})}{\text{truck capacity}}$$

$$= \frac{(\$43./\text{hr})(2.5\ \text{hr})}{9.54\ \text{Mfbm}} = \$11.27/\text{Mfbm}$$

Cost of sawlog delivery = 11.27 S

where S = annual sawlog production (Mfbm)

The plan for chip production calls for chips to be loaded directly into truck vans. For road and rail transport, a 24 hour storage capacity and a 48 hour storage capacity will be required, respectively. Therefore, spare chip vans will have to be leased.

Information about leasing a standard 40 ft, 25 tonne capacity chip van was obtained from personnel of the Newfoundland Department of Forest Resources and Lands.

Cost of chip storage

$$= \frac{\text{storage time (chip van rental rate/day)}}{\text{van capacity}}$$

$$= \text{storage time}\ \frac{\$18./\text{day}}{25\ \text{green tonnes}} = \$0.72/\text{green tonne/day}$$

road: 1 day storage = \$0.72/green tonne

rail: 2 day storage = \$1.44/green tonne marine:

For marine mode of transportation, only one spare van is required since the vans will only be used for short distances to dockside in Clarenville and are not involved in further transit. Therefore, the cost is a fixed one. When both barges are away from Clarenville (one docked in Botwood and one in transit), chips will have to be stockpiled on site and be loaded into vans by the front-end loader when a barge returns. (front-end loader and operator cost included in processing cost).

For marine transport, a 72 hour stockpile is required because of the transport time for the tug - 2 barge system is approxomately 35 hours. This is based on using a tug of 1200 HP which would travel at an average speed of 7 to 8 knots. Therefore, a reasonable return trip time for delivering a loaded barge and returning an empty one is 72 hrs or three days. The barge is expected to carry 2,000 tonnes each trip to market.*

At Botwood the barge will have to be unloaded. The chips will then have to be loaded onto waiting trucks for the relatively short haul to Grand Falls. Cost of unloading at Grand Falls is absorbed by the buyer - Abitibi-Price Inc., as is the custom for them at this time. This is reflected in the low prices they pay.

* All data about marine mode of chip transport supplied by Mr. James Brown, Vice President of Genstat Marine. He is the only individual representing a marine carrier firm who would respond to questions issued.

Cost of transport and handling of chips by marine mode:

spare chip van rental = ($18./day)(200 days) = $3,600

transport of chips from site to dockside Clarenville (5 km)

= (truck & driver wage rate)(time)

= ($43./hr)(8 hr/day)(200 days/yr) = $68,800

2 barge - 1 tug freight rate:

barge rental - $750/day

tug rental - $6000/day

barge capacity - 2000 tonnes

round trip time from Clarenville to Botwood

= 72 hr. = 3 days

(250 nautical miles @ 7 to 8 knots)

annual cost for 2 barges

= 2($750/day)(200 days/yr)

= $300,000

Whether or not the barges are in transit, their rental must be paid.

When docked in Clarenville, a barge will be a floating storage facility.

$$\text{tug cost} = \frac{(\$6000/\text{day})(3\ \text{days/trip})}{2000\ \text{tonnes/trip}}$$

= $9.00/tonne

∴ marine travel cost =

= tug cost + annual cost for 2 barges

= $9.00/tonne + $300,000

loading cost in Botwood

= (front-end loader rental rate)(loading time)

= (22./hr)(1 hr/25 tonne)

= \$0.88/tonne

transport of chips from Botwood to Grand Falls (35 km)

$$= \frac{\text{(truck \& driver wage rate)(round trip \& loading times)}}{\text{truck capacity}}$$

$$= \frac{(\$43./\text{hr})(2\text{ hr travel time} + 1\text{ hr loading time})}{25\text{ tonnes}}$$

= \$5.16/tonne

Chip transport from the site to Clarenville dockside requires one truck and one driver always available.

Chips are to be dumped onto the barge at Clarenville, therefore unloading time is considered negligible.

cost of chip delivery by marine mode:

chip storage	\$ 3600
trucking to Clarenville dockside	\$68,800
marine travel cost	\$9.00/tonne of chips + \$300,000
loading cost at Botwood	\$0.88/tonne of chips
trucking from Botwood to Grand Falls	\$5.16/tonne of chips
	\$15.04/tonne of chips + \$372,400

For road transport, the situation is simple because there is no transfer of chips. The loaded vans will be hauled directly to Grand Falls. This is considered a long haul on good roads since only 5 of the 245 km of the haul from Shoal Harbour to Grand Falls is on secondary roads.

Therefore, distance rate will be applied for the truck and driver in the cost analysis.

Cost of transport and handling of chips by road mode:

Only 24 hr. storage is required because it is assumed empty vans will be returned within 24 hours after leaving the site with the chips.

Chip storage = $0.72/green tonne

trucking from Shoal Harbour to Grand Falls:

$$= \frac{(\text{trucking rate/distance})(\text{round-trip distance})}{\text{truck capacity}}$$

$$= \frac{(\$0.85/\text{km})(490\ \text{km})}{25\ \text{tonnes}} = \$16.70/\text{tonne}$$

cost of shipping by truck = storage + trucking

= $17.42/tonne of chips

Rail transport will utilize the "piggy-back" system to eliminate chip handling. Chip vans will be taken by road to the Clarenville station for loading onto the train, taken to Grand Falls and taken off the train. This way there is no direct handling of chips until the van arrives at the mill, just transfers of the van itself. The empty vans will be returned by rail the following day.*

Cost of transport and handling of chips by rail mode:

chip storage at site = $1.44/tonne

A 48 hr. storage is required because of the uncertaninty that empty chip vans will be returned before processing

* A member of the CNR, the only railway carrier in Newfoundland supplied pertinent data necessary for cost computation.

the following day.

This is a similar situation as the trucking to dockside for the marine mode except the chip van is left at the station and a different chip van collected and returned to the site. Two vans, one truck and driver must always be available. Therefore, this transport cost is fixed.

transport of chips from site to Clarenville station (5 km)

= \$68,800

railway transport cost

$$= \frac{(\text{"piggy-back" unit cost})}{\text{unit capacity}}$$

$$= \frac{\$450/\text{unit}}{25 \text{ tonnes}} = \$18./\text{tonne}$$

cost of chip delivery by rail mode

chip storage	\$1.44/tonne of chip
trucking to Clarenville station	\$68,800
rail transport	\$18.00/tonne of chips
	\$19.44/tonne of chips + \$68,800

Cost estimates for road transport are established from past records and are reliable in the sense that they are based on historical data. However, rail and marine costs were supplied by operators who stressed the point that although the estimates are reasonable indicators of costs, in an actual situation there would be negotiations to obtain mutually acceptable freight rates.

Freight rates are computed with the expectation that there will be no back-haul from Grand Falls for any of the

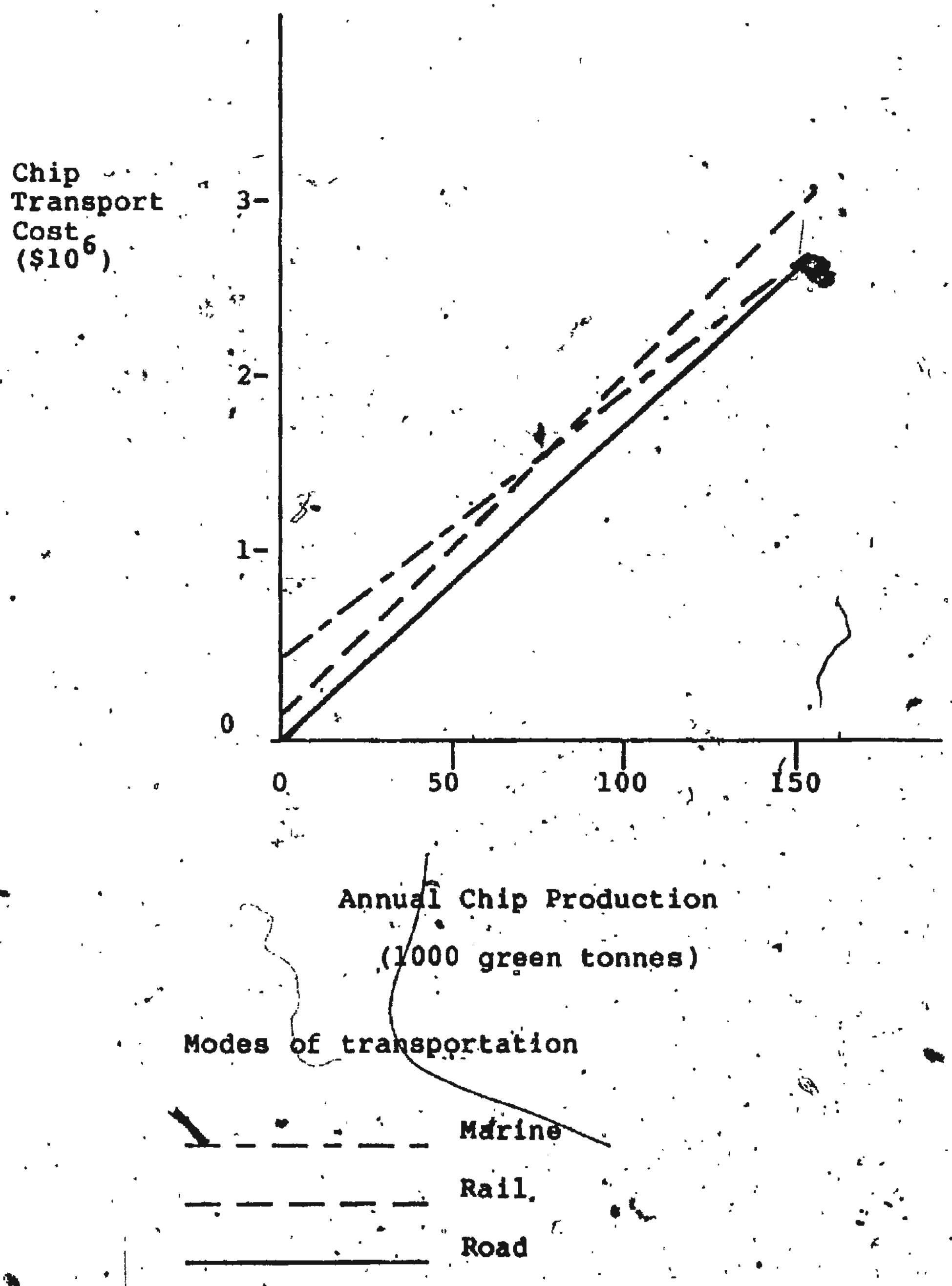

Figure 4. Cost of Chip Transport to Market.

modes of transportation. A cost of chip transport by annual chip production relationship was established for the three modes of transportation (Figure 4). The linearity of the graph is assumed, not proven.

The model equation which determines the contribution of product transportation to the annual operating cost of the integrated logging proposal is a summation of the sawlog and chip delivery cost. The chip delivery cost can be examined for the three modes of transportation (road, rail and marine), where storage, transfer and transport features of each mode is expressed as a constant plus variable chip production cost. The fixed cost for transport and handling of chips is expressed by the variable "K"; the variable costs by the variable "T". These variables have set values for each mode of chip transport.

$$C(3) = 11.27S + T(Q) + K$$

where S = annual sawlog production (Mfbm)

Q = annual chip production (green tonne)

T = transport and handling unit cost for chips (variable)

K = chip delivery cost constant (fixed)

4.2 Costing Model Summary

The costing model developed to determine the total annual operating cost of an integrated sawlog-pulpwood-fuelwood site in Forest Management Unit 2 is comprised of a set of three equations; the sum of which will predict the cost of the stated operation. The set of equations can be termed pedagogical because it attempts to reduce the complexity of the "real" situation into a manageable framework which eliminates much of the details considered inconsequential to the actual relationship between the chosen parameters and the prediction. The equations can also be termed realistic in that they are based on "reasonable" and logical assumptions.[11]

MODEL

Cost of wood procurement: C(1)

$$C(1) = 22.78\ TL + 25.55\ SW + 5.00\ R$$

Cost of processing: C(2)

$$C(2) = 340{,}000\ CRF + 7.11\ P + 1.25\ F + 126{,}200$$

Cost of transportation to market: C(3)

$$C(3) = 11.27\ S + T\ (1.45\ P + F) + K$$

where, TL = volume of tree-length wood delivered to the site (m^3)

SW = volume of shortwood delivered to the site (m^3)

R = sawmill residue delivered to the site (green tonnes)

CRF = capital recovery factor, at known rate of return "i" for a set time period "n"

P = pulpwood chip production (bone dry tonnes)

F = fuelwood chip production (green tonnes)

S = sawlog production (Mfbm)

T = transport and handling unit cost for chips (variable cost)

K = chip delivery cost constant (fixed cost)

Table 4.9 Constants associated with product transportation mode in model equation

	Mode of Transportation		
constants	road	rail	marine
T	17.42	19.44	15.04
K	0	68,800	372,400

Model restraints:

The application of the developed model is limited in two ways by nature of the integrated logging scheme. Quantity of raw material harvested and processing capacity of equipment and manpower both place restrictions on the range for parameter values or combined parameter values.

The amount of wood delivered to the site for processing is restricted by the AAC established for expanded forest industry (85,000 m^3). Therefore, the combined value of tree-length wood and shortwood volumes delivered to the site should not exceed 85,000 m^3.

$$TL + SW \leq 85{,}000 \ m^3$$

Maximum production capacity of processing equipment (debarker, chipper) places constraints on chip production. Total chip production (pulpwood and fuelwood) would be restricted by the chipper to 28 tonnes/hr which would be equivalent to the annual production of 44,800 tonnes/yr. Therefore, the combined green weight of pulpwood and fuelwood must be less than or equal to 44,800 tonnes annually.*

$$1.45\ P + F \leq 44{,}800 \text{ green tonnes.}$$

The minimum annual production of pulpwood is 17,200 bone dry tonnes. This is based on the assumption that both debarkers will be operating at full capacity for at least 8 hours, for 200 days. Otherwise the model will predict lower processing costs than would otherwise be indicated.**

$$P \geq 17{,}200 \text{ bone dry tonnes}$$

* If the total AAC for the integrated logging scheme were chipped (85,000 m^3), then the chip production would be equivalent to 44,200 green tonnes, which is roughly equivalent to the chipper annual production capacity of 44,800 green tonnes. Therefore, these two types of restraints appear to set a maximum chip production at approximately the same point. It also indicates that 1 chipper on one 8 hr shift is sufficient for the proposed operation providing machine availability is maintained for the 200 day production period.

** This minimum annual production of pulpwood chip value implies that the amount of raw material harvested must be equal to or greater than 48,000 m^3 for the year.

$$TL + SW \geq 48{,}000 \ m^3$$

All sawmill residue will become fuelwood because its quality renders it unsuitable for pulpwood. Therefore, fuelwood production must always exceed or be equal to the amount of sawmill residue delivered to the integrated logging site.

$$F \geq R$$

Sawlog production should not exceed 800 Mfbm annually. Otherwise, processing costs will be higher than anticipated by the model.

$$S \leq 800 \text{ Mfbm}$$

The restraints and constraints other than the one concerning residue are not physical limitations, but rather restrictions on the range set by assumptions made during model development.

4.3 Testing of Costing Model

Model validity is shown to be acceptable when exposed to the reality of the situation and results are accurate. However, due to the inability to conduct actual trials of the proposed plan for the integrated logging site, results from other comparable operations will have to be used as substitutes in order to examine the model's predictive accuracy (Appendix C).

The specific conditions of the Bonavista Peninsula proposal made it impossible to find previous studies which were similar to it in all respects. An attempt was made to examine results from studies which possessed as many of the proposal's characteristics as possible, namely integrated system which involved the chipping process.

Testing of the model will also be done in two parts. In one part, the procurement and processing aspects will be examined; in the other, the product transportation to market. The splitting of the model testing has to be conducted in this manner due to the inability to achieve access to results of a similar integrated logging scheme which would encompass all the phases of the operation.

Adjustments for time differences are made in order to relate historic data to 1982 costs. Up to 1980 a 10% inflation rate will be used; from 1980 to 1982, 15% will be used.

4.3.1 Testing of Procurement and Processing Aspects of the Proposed Integrated Logging Site

Three sets of results were obtained which have some aspects of similarity to the proposed plan for procurement and processing. However, all three studies involved whole-tree harvesting operations with processing and short distance transport to market, not short distance transport of tree-length and shortwood harvested wood to a central landing.

Case #1 Whole Tree Harvesting in Prince Edward Island[16]

This operation was an integrated system carried out on Prince Edward Island in 1977. Fuelwood chips and studwood (8 feet sawlogs) were produced. The duration of cost analysis of the study was nine days. Costs and production were projected for a 200 day production period. Delivery distance of chips was 48 km. Sawlog delivery was 8 km.

Case #2 Integrated Logging for Production of Pulpwood and Hog Fuel (trial 1)[9]

Abitibi-Prince Inc. trial 1 and ENFOR Project P-143 was conducted in 1980 with costs and production data tabulated for 11 days. Information was extrapolated for 200 days. Only fuelwood chips were actually produced in this trial. Truck delivery was approximately 20 km.

Case #3 Integrated Logging for Production of Pulpwood and Hog Fuel (trial 2)[9]

Trial 2 of ENFOR Project P-143 was an integrated operation in which fuelwood chips, pulpwood, roundwood, and sawlogs were all produced. This trial was carried out for 22 days. Again, costs and production were projected for 200 days. Material delivery was approximately 20 km. The projected costs were compared and presented in Table 4.10. Tabulation of values are shown in Appendix C.

Table 4.10 Test results for procurement and processing aspects of the model

	Actual Operating Cost (projected)	Time Adjusted Cost	Model Cost
Case #1	$ 223,420	$ 393,280	$ 598,320
Case #2	1,293,440	1,710,575	1,712,045
Case #3	708,736	937,304	1,540,810

The cost differences between the various cases and the model are given in Table 4.11

Table 4.11 Percentages and difference of test results for procurement and processing.

	Actual Operating Cost (projected) % difference	Time Adjusted Cost % difference
Case #1	63 less	34 less
Case #2	24 less	1 less
Case #3	54 less	39 less

4.3.2 Testing of Product Transport to Markets Aspects Marine Mode

The cost value for this mode of transportation is taken from a Newfoundland government study [12] conducted by Sandwell Consultants for a 1 barge – 1 tug operation from the Northern Peninsula to Goodyear's Cove, a distance of about 150 nautical miles. Production estimate was 30,000 cords per year (72,000 m^3/year).

Actual values obtained for this part of the test are unit values. Therefore, in order to show a comparison with the model in a tabular form, a production figure must be assumed. For this, the production of 37,500 green tonnes of chips annually was used. This figure represents the equivalent chip production used in the marine mode testing.

Unit costs for road and rail were obtained from a 1980 Canadian Transport Commission report.[17] Graphs were produced for both road and rail transport costs/distance versus distance. For truck hauling, there were two sources of useful cost information shown in this report: (1) operating costs based on a previous Transport Canada study "Operating Costs of Trucks in Canada, 1978"[18], and (2) operating costs obtained from a survey of truck users. For rail transport, costs were obtained from a special rail traffic compilation by the Canadian Transport Commission. Tables 4.12 and 4.13 contain the results of cost comparisons for the various transportation modes. Calculations of these results are shown in Appendix C.

Table 4.12 Test results for product transportation to market aspect of the model

	Actual Operating Cost (projected)	Time Adjusted Cost	Model Cost
marine mode	$1,860,600	$2,460,640	$ 937,660
rail mode *	485,100	641,545	797,800
road mode (CTC survey)	330,750	437,417	653,250
road mode (user study)	522,625	558,922	653,250

Table 4.13 Percentage difference of test results for product transportation to market

	Actual Operating Cost (projected) % of difference	Time Adjusted Cost % of difference
marine mode	98 more	162 more
rail mode	39 less	19 less
road mode (CTC study)	49 less	33 less
road mode (user study)	35 less	14 less

* This value is from the ".80'Carload' (train)" curve of the CTC graph of haul rates by mode and is used to equate volume handled in a truckload. Use of this curve is a reasonable decision since the proposal involves the "piggy-back" of truck trailers. This value is also for a distance of 400 km., the minimum distance shown for this curve.

4.4 Benefits

The benefits of any viable forest industry expansion into the Bonavista Peninsula are multi-faceted. There is the obvious economic advantage of having increased cash flow into the area from the sale of the forest products. There is also the socio-economic aspect of employment stimulation and industry expenditures which would likely have a rippling effect on communities involved with the integrated logging scheme. Lastly, there is the environmental impact of reducing the amount of hygrading practiced and of clearing land for future silvicultural improvement, as well as solving the sawdust accumulation problem.

4.4.1 Financial

The degree of financial gain (or loss) in establishing a multi-product logging site in Forest Management Unit 2 is based on the cost and benefit relationship. Although the costs are estimated as reasonably as deemed possible, the economic benefits (payments for supply of forest products) are basically set by the forest product market. At present, the 1982 forest product prices are as follows:

Table 4.14 Purchase price of products

Product	Purchase Price	Market
Sawlogs *	$100/Mfbm	local Bonavista Pen. area sawmills
Pulpwood chips **	$ 83/bone dry tonne	Abitibi-Price Inc. in Grand Falls
Fuelwood chips	$ 23/green tonne	Abitibi-Price Inc. in Grand Falls

4.4.2 Socio-economic

The socio-economic benefits of job creation and the community-wide rippling effect of capital investment and operational expenditures are not so simple to appraise as the strictly economic aspects. If the impact of direct income and employment on indirect income and employment follows the trend of the sawmill and planing mill industry in the Bonavista Peninsula as determined by Environment Canada through the Newfoundland Forest Research Centre [6], the following results could be expected:

- 33% of the direct wages circulated back into the area
- 50% of the circulated direct wages become indirect income

* Price subject to market fluctuations and negotiations

** Although the readily measureable weight of chips is based of the "green" weight, it is policy for pulpwood chips to be purchased on the basis of "bone-dry" weight in order to avoid paying for anything other than wood substance.

- industry monies and direct wages channelled into the Bonavista Peninsula area communities would result in indirect person-years employment approximately equal to 14% of the direct number employed by the proposed expansion of the forest industry.

A cost effectiveness monetary value placed on socio-economic advantages is difficult. After assessing percentages of projected direct and indirect impacts on employment and income, it seems direct and indirect employment in person-years attributible to the operation of an integrated logging site can be manipulated to express the qualitative value of socio-economic benefits in a quantitative way.

Direct person-years is estimated to be 191 person-years/100,000 m^3 of roundwood produced.[3] If this value is extended to the proposed integrated logging operation, it can be stated that 1 person-year is created for every 1000 green tonnes of chips produced.

$$\frac{191 \text{ pers-yrs}}{100{,}000 \text{ m}^3} \times \frac{0.522 \text{ green tonnes of chip}}{\text{m}^3} = .001 \frac{\text{pers-yrs}}{\text{m}^3}$$

Indirect employment is estimated to be 14% of direct employment.[6] Therefore the employment figure can be revised to 1.14 person-years/1000 green tonnes of chips.

One way of expressing a "person-year" in terms of a monetary value is to consider the equivalent savings in welfare and unemployment benefits. This result could be considered a conservative estimate by some standards since a man's self-esteem in being employed is immeasurable.

Welfare and unemployment payments made by either the Newfoundland and Canadian governments are so varied that a precise value is unobtainable. Therefore, a "ball park" figure of $5000/person-year will be used. This value is an approximation of what an out-port family of 6 would receive from the Newfoundland government in welfare payments. This figure was given to the author by welfare recipients.

Therefore, a monetary value placed on employment potential can be stated as:

$$\frac{\$5000}{\text{pers-yr}} \times \frac{1.14 \text{ person-year}}{1000 \text{ green tonnes chips}} = \$5.70/\text{green tonne chip}$$

4.4.3 Environmental

Environmental benefits would result from implementing the plan for a clear-cut harvest. Full utilization of the Bonavista Peninsula forest would open large tracts of land for establishment of silviculturally imposed regeneration patterns. Also, it would deplete the area of what has been labeled "green junk"[19] (poor quality standing timber, left following mismanagement of the forest resource), as well as convert the wood to a marketable product.

The extremely high cost of clearing poor stands is estimated at $1300/ha.* Inventory results show the

* This information supplied by the Newfoundland Forest Research Centre of Environment Canada.

productive forest lands of Forest Management Unit 2 cover approximately 146,000 ha and have an estimated wood volume of 10,000,000 m^3.[7] These two figures translate into a wood volume per area of 68.5 m^3/ha. Stand volumes are usually estimated for each site class and species; but for this general application of volume per unit area, this overall average of 68.5 m^3/ha is acceptable.

By converting m^3/ha to green tonnes of chips/ha, using the equivalents shown in Appendix A, the unit value of 35.7 green tonnes chip/ha is obtained.

$$(68.5 \text{ m}^3/\text{ha})(0.522 \text{ green tonnes chip/m}^3)$$

$$= 35.8 \text{ green tonnes chip/ha}$$

This means that 35.7 green tonnes of chips can be produced from a hectare of land with a clear-cut. Therefore a savings due to the elimination of stand clearing as a silvicultural treatment can be expressed by

$$\frac{(\$1300/\text{ha})}{(35.8 \text{ green tonnes chips/ha})} = \$36.30/\text{green tonne chip}$$

The problem of sawdust accumulation at the sawmills and planer mills in the area would be reduced by setting up the integrated logging site because their waste would be transformed into goods of value, irrespective of how marginal that value is, simply because the proposed operation would be willing to purchase it.

An additional possible benefit to the forest industry as a whole with respect to management of the resource could be the elimination of some of the low production part-time sawmills in Unit 2. This could result from the operators of these sawmills converting from harvesting and milling to just harvesting since there now would be no need for them to further process the wood in order to obtain a market. A market for their felled wood would be available at the integrated logging site. (This transfer of employment into harvesting could mean that the increase in employment is less that anticipated.)

Benefits, whether tangible or intangible, must be sufficiently high to offset the required monies for the operation of an integrated sawlog-pulpwood-fuelwood logging site in the Bonavista Peninsula area. Otherwise, the proposal is not feasible. This is why an economic evaluation is carried out prior to initiation of a proposed plan.

4.4.4 Benefits Summary

The benefits considered for the economic evaluation are the financial, socio-economic, and the environmental. Financial benefits (B(1)) represented by the monies accrued through sales of the wood products. The socio-economic benefits (B(2)) are estimated by translating person-years of employment into monies per green tonne of chips. Alteration of the present regeneration pattern by carrying out a clear-cut logging operation is the primary environmental advantage to the integrated logging proposal. Therefore, the benefits attributed to this aspect of forest improvement is the basis for setting the environmental benefits (B(3)).

For both the socio-economic and environmental benefits, the estimation of their contribution is expressed as monies per green tonne of chips. No benefits are attributed to sawlog production because the intent of establishing an integrated operation was not to expand the present sawmill industry, but rather to supply the dwindling supply of acceptable-sized logs. Therefore the qualitative benefits are applied only to the fuelwood chips and pulpwood chips produced.

Financial benefits: B(1)
$$B(1) = 100\ S + 83\ P + 23\ F$$

Socio-economic benefits: B(2)
$$B(2) = 5.7\ (1.45\ P + F)$$

Environmental benefits: B(3)
$$B(3) = 36.3\ (1.45\ P + F)$$

The summation of the three benefits will yield total annual benefits:

$$B = 100\ S + 144\ P + 65\ F$$

Where, S = sawlog production (Mfbm)

P = pulpwood chip production (bone dry tonnes)

F = fuelwood chip production (green tonnes)

4.5 Benefit-Cost Analysis

A benefit-cost analysis is part of an economic decision procedure which considers qualitative and quantitative benefits as well as costs. With such an analysis the ratio of accrued benefits over expended costs is examined. If the ratio is greater than 1, the alternative proposal is feasible. To select the "best" alternative, an incremental analysis of possible atlternatives is done.

For the integrated logging site proposal, there are numerous variables. This means there is no one acceptable solution. Availability of wood and market condition could limit the production level. Therefore, an almost infinite number of conditions can be analyzed, even though it is known that the "best" solution would be maximum allowed production (set by AAC) and sale of products.

Examples of B/C Application

Situation #1:

- all wood delivered as TL
- minimum production of pulpwood (set by model constraint)
- no residue delivered
- CRF is for i = 12% for 20 years
- road transport of chips
- no fuelwood chips produced

∴ SW = 0
TL = 48,000
R = 0
CRF = 0.13388
P = 17,200
F = 0
S = 0
T = 17.42
K = 0

B = 2,475,000
C(1) = 1,093,400
C(2) = 294,000
C(3) = 434,400
C = C(1) + C(2) + C(3) = 1,821,800

B/C = 1.36

Situation #2:

- all wood delivered SW
- minimum production of pulpwood (set by model constraints)
- no residue delivered
- CRF is for i = 12% for 20 years
- road transport of chips
- no sawlogs produced
- no fuelwood chips produced

∴ SW = 48,000
TL = 0
R = 0
CRF = 0.13388
P = 17,200
F = 0
S = 0
T = 17.42
k = 0

B = 2,475,000
C(1) = 1,226,400
C(2) = 294,000
C(3) = 434,400
C = C(1) + C(2) + C(3) = 1,954,800

B/C = 1.27

Situation #3:

- all wood delivered TL
- minimum production of pulpwood
- no residue delivered
- CRF is for i = 15% for 20 years
- road transport of chips
- no sawlogs produced
- no fuelwood chips produced

∴ SW = 0
TL = 48,000
R = 0
CRF = 0.15976
P = 17,200
F = 0
S = 0
T = 17.42
K = 0

B = 2,475,000
C(1) = 1,093,400
C(2) = 302,800
C(3) = 434,400
C = C(1) + C(2) + C(3) = 1,830,600

B/C = 1.35

Situation #4:

- 1/2 wood volume delivered TL; 1/2 delivered SW
- residue delivered
- CRF is for i = 12% for 20 years
- road transport of chips
- pulpwood chips, fuelwood chips, and sawlogs produced

∴ SW = 24,500
TL = 24,500
R = 2000
CRF = 0.13388
P = 17,200
F = 2000
S = 212
T = 17.42
K = 0

B = 2,626,00
C(1) = 1,194,100
C(2) = 296,500
C(3) = 471,600
C = C(1) + C(2) + C(3) = 1,962,200

B/C = 1.34

Situation #5:

- all wood delivered TL
- maximum production of chips
- residue delivered
  (maximum @ 25% sawmill AAC = 8000 m^3
  = 4200 green tonnes)
- CRF is for i = 12% for 20 years
- road transport of chips
- fuelwood production set at estimated amount of
  hardwood delivered (8% of 85,000 m^3 plus
  residue
- maximum sawlog production (set by model
  constraint)
- remainder of wood for production of pulpwood
  chips

$$\therefore \begin{aligned} SW &= 0 \\ TL &= 85{,}000 \\ R &= 4200 \\ CRF &= 0.13388 \\ P &= 25{,}550 \\ F &= 9300 \\ S &= 800 \\ T &= 17.42 \\ K &= 0 \end{aligned}$$

$$\begin{aligned} B &= 4{,}363{,}700 \\ C(1) &= 1{,}957{,}300 \\ C(2) &= 365{,}000 \\ C(3) &= 815{,}900 \\ C &= C(1) + C(2) + C(3) = 3{,}138{,}200 \end{aligned}$$

$$B/C = 1.39$$

The B/C is acceptable for all examples of possible situations. As is logical, the best alternative examined is maximum production (situation #5).

However, for private industry, the only benefit that may be significant to them is the financial benefit. By examining B/C when only sales revenue is considered, even the best situation is not acceptable.

financial benefit = B(1) = B'

B' = 100 S + 83 P + 23 F

where, S = sawlog production (Mfbm)
P = pulpwood chip production (bone dry tonnes)
F = fuelwood chip production (green tonnes)

Situation #5:

B' = 2,414,500
C = 3,138,200

B'/C = 0.76

Table 4.15 summarizes the results of B/C for example situations.

Table 4.15 Summary of benefit-cost analysis

Situation	B	C	B/C	B'	B'/C*
#1	2,475,000	1,821,800	1.36	1,427,600	0.78
#2	2,475,000	1,954,800	1.27	1,427,600	0.73
#3	2,475,000	1,830,600	1.35	1,427,600	0.78
#4	2,626,000	1,962,200	1.34	1,494,800	0.76
#5	4,363,700	3,138,200	1.39	2,414,500	0.77

* B'/C is a ratio which considers only financial benefit and ignored environmental and socio-economic aspects.

CHAPTER 5

DISCUSSION OF RESULTS

5.1 Costing Model Development

The set of model equations developed to express the annual cost of operating an integrated logging scheme in the Bonavista Peninsula area is based on three types of variables: the time value of money, production (input and output) characteristics, and transportation characteristics. Time value of money is a reference to the use of the capital recovery factor for the processing phase of the economic evaluation; the production characteristics are a reference to the quantity of each wood form delivered to the site and the forest product yields; and the transport variable "T" and the transport constant "K" are used to indicate modal choice for product delivery to market.

The cost estimates which went into the model development are meant to be as realistic as possible. Variable co-efficients and constants associated with the model equations are dependant on these estimates. In turn, unloading and loading at terminals, skill of operators, and control over handling and storage (scheduling) are prime factors which could alter the validity of the assumptions which determined the numeric values of the co-efficients and constants. Reliability of historical cost information and expert advice is essential.*

Acceptance of the cost estimates used in the development of the costing model is a very important step in accepting the accuracy of the model itself. Many of the estimates were historical in nature and an inflation rate was applied to them in order to indicate escalating costs. The assumption that the chosen rate is accurate and that all costs increased uniformly must be considered in establishing validity of the model equations.

The effect of a discrepancy between the actual costs and predicted costs can be shown by conducting a sensitivity analysis. With a sensitivity analysis, the input information is altered and the corresponding change in the output can then be examined. (The number of components of the model makes it difficult to analysis sensitivity of each.)

For equipment; repair, fuel, and labour are the primary contributors to equipment operating cost. Although fuel costs have been of major concern in recent history; by examining percentage contribution to variable processing costs (Table 4.8), it is seen that repair has almost 3 times the contribution of fuel and labour has about twice that of fuel. It seems reasonable that properly or poorly trained equipment operators can have a great influence on repair

* Terra-Transport, Genstar Marine, Nfld. Department of Forest Resources and Lands, and the Newfoundland Forest Research Centre of Environment Canada personnel were consulted about aspects concerning their expertise.

cost which in turn can have a great influence on actual operating cost. For trucking, the same primary contributors influence the variable operating costs (Table 4.5). However, in the case of trucks, fuel has a much greater influence, repair less influence, and labour has slightly more influence on the overall truck operating costs in comparison to processing equipment cost percentages for the same factors. This labour cost is especially of concern in Newfoundland where the majority of truckers are not unionized and their wages are subsequently lower than elsewhere.

The constants of the model equations are meant to be reflective of current costs. Therefore, the equations are not valid for predicting future costs. Their use is restricted to determining present costs under varying characteristics of the operation. In order to use the model for predicting future costs, an inflationary adjustment must be applied. This adjustment could be done by considering an appropriate compound amount factor, assuming all costs will increase uniformly.

The conversion factors relating wood volume to green wood density are based on 45% moisture content (MC). The reason for choosing this value is because studies [15], [16] indicated the average MC of wood chips used at the mill during trial runs was approximately 45%. The specific gravity value of green wood, which also is required to relate volume to weight, is based on Eastern spruce. A greater content of fir or hardwoods in the fuelwood chips is not expected to be different from the actual value by more than 5%. Bark contribution to the specific gravity value is taken as being negligible.

The decision of whether to produce pulpwood chips or fuelwood chips is one which affects both costs and benefits. The sensitivity of costs, revenue, and total benefits to product choice with respect to fuelwood chips and pulpwood chips is shown in Figure 5. The costs represent maximum tree-length wood volume being processed for chips as set by the model constraints and the products being trucked to their destination. Revenue is based on sale of all products. This figure shows that with an increase in fuelwood produced, costs decrease slightly, whereas revenue and total benefits decrease rapidly.

The sensitivity of wood delivery length to the annual operating cost is shown on Figure 6. Annual costs are based on full capacity production and truck delivery to market. The curve indicates that a volume increase in shortwood and corresponding volume decrease in tree-length wood results in increased annual operating costs. Over the range of values from 0% to 100%, the annual cost varies approximately 6%.

The transportation of sawlogs to local sawmills is restricted to one mode, road transport. However, chip transportation to market in Grand Falls was examined for each of the three modes - rail, road and marine. It was found that rail was the least economical; road, the most straight forward approach and the most economical for the lower range of chip production; and marine, although requiring more control over scheduling that trucking, was potentially the least expensive way to ship chips when production exceeded 156,470 green tonnes which is about 3 1/2 times the maximum production. Therefore, within the chip production restraint of the proposal, chip transportation also is restricted by economics to trucking.

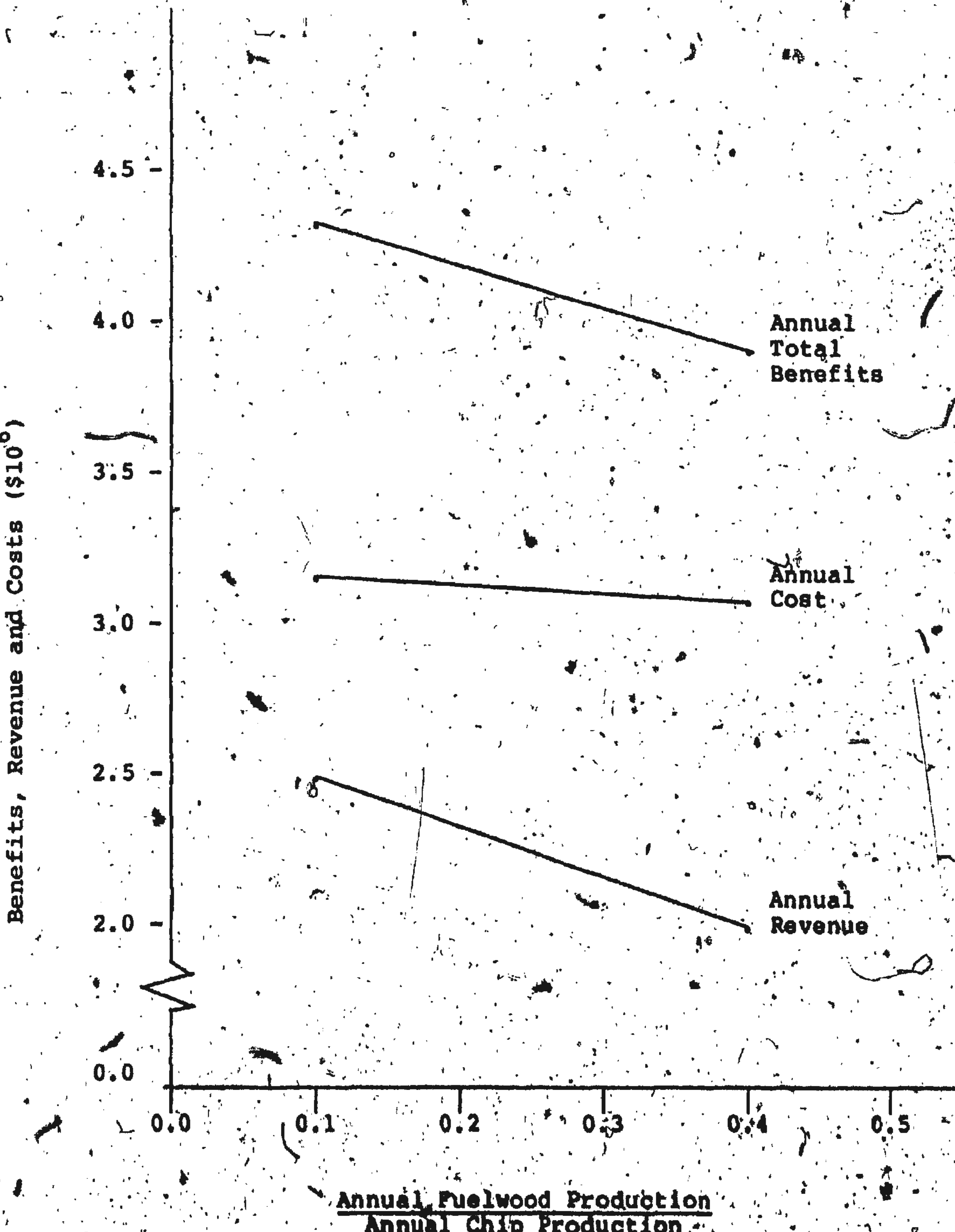

Figure 5. Full Capacity Production Cost, Revenue, and Total Benefits Sensitivity to Fuelwood Production.

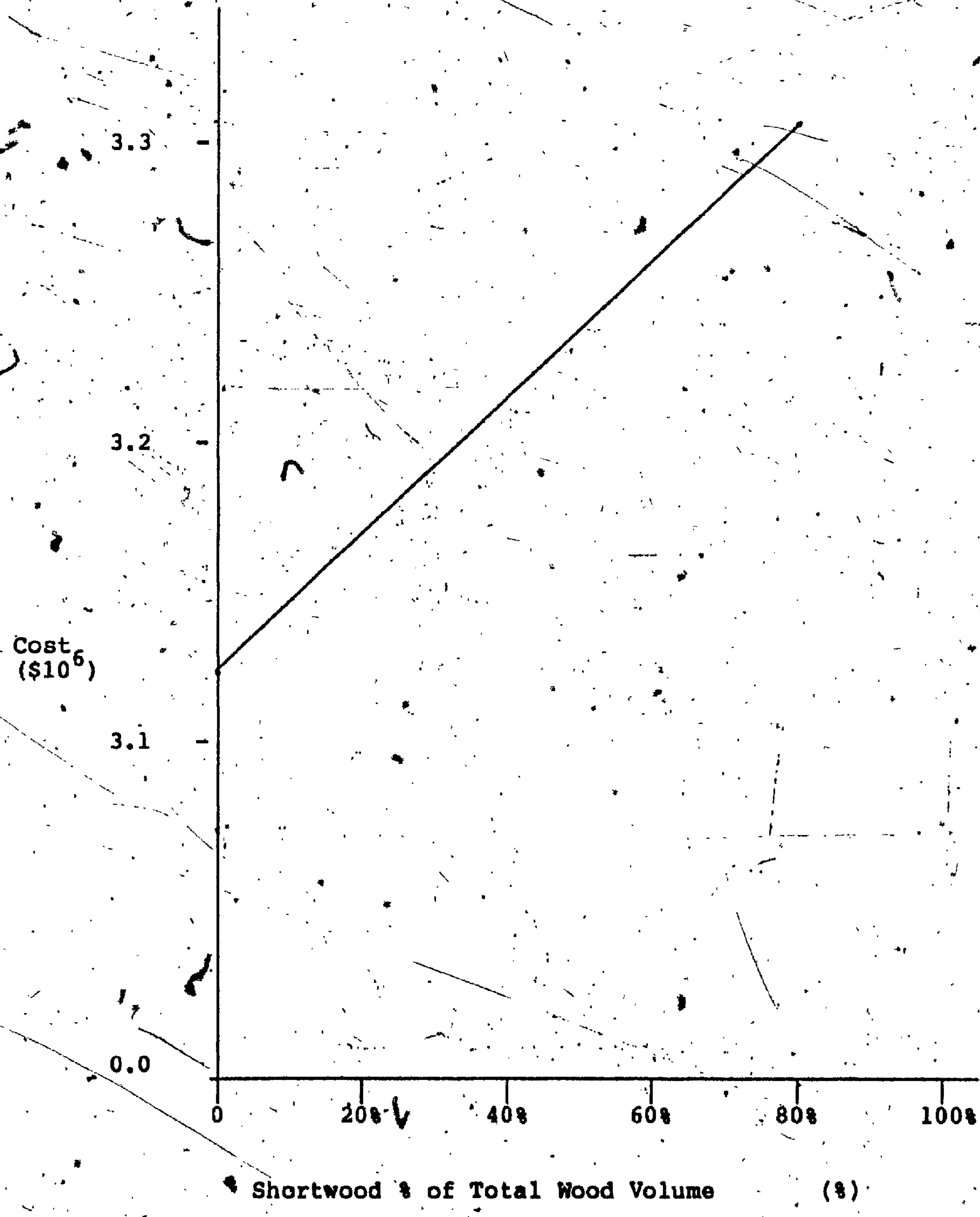

Figure 6. Full Capacity Production Cost Sensitivity to % Shortwood Delivered to Integrated Site.

5.2 Costing Model Testing

Testing results of the procurement and processing aspects of the model were inconsistent. The values for the time adjusted (projected) actual operating cost and the cost predicted by the model varied considerably in Case #1 and #3, whereas for Case #2 they were uncannily close.

For all three cases, the (projected) actual production is less than the minimum production established for the Bonavista Peninsula operation. Manpower requirements and capital cost of processing and handling equipment for the proposed integrated operation are incorporated in the model. Therefore, actual costs of operations which do not utilize as much manpower and equipment as the proposed operation are expected to be significantly lower than those forecast by the model. Also the difference between logging system (whole tree versus tree-length and shortwood harvesting) of the test cases and that of the proposed logging system for which the model was developed could be significantly different as to render the testing of the procurement and processing aspects of the model as meaningless.

The insupportability of the model by the tests may also be attributable to the accounting technique used in determining cost values. It is questionable whether the studies quoted actual costs or cost allocations.

For transportation of products to market, test results for road and rail modes indicated reasonable acceptance of the model. However, the predicted cost for the marine mode was less than half the time adjusted actual cost and understates an unreasonableness, either in the model or in the assumption of similarity between the test situation and the model situation.

It is questionable whether the marine mode situation used to test the model was an acceptable choice. Excessive handling and waiting time associated with the 1 tug - 1 barge roundwood operation may have been translated into costs exorbitantly different from the predicted cost of handling the equivalent amount of chips in a 1 tug - 2 barge proposed transport system. Also, it should be pointed out that the cost was a prediction itself, not an actual cost.

The specific application of the model to the stated proposal leads to inconsistency in testing. Validity is still questionable on the basies of the test results. However, this does not mean that the model is not reliable for its intended purpose.

5.3 Benefits

Expected revenue was based on revenues collected by operations being carried out presently. Socio-economic and environmental benefits were estimated by assigning monetary values to abstract aspects of an integrated logging operation. Unlike cost estimates whose accuracy can be guaged by comparison with historical information, these qualitative benefits can not be pronounced valid even in retrospect. The accuracy of the values assigned to these benefits is "all in the eye of the beholder".

The qualitative benefits (socio-economic and environmental) are very important when considering the feasibility of the integrated sawlog-pulpwood-fuelwood logging operation. When they are not considered, the operation is not feasible even under the best conditions. When they are considered, it is feasible under a "minimum situation".

5.4 Benefit-Cost Analysis

Benefit-cost analysis may indicate the best combination of product selection for maximum gain, but actual operating and market conditions may make the optimum conditions unobtainable.

Benefit-cost ratios were determined in two analyses. First, benefit-cost ratios were established for total benefits; then, benefit-cost ratios were calculated with only benefits that private enterprise may consider ie. revenue. This second analysis may seem an inappropriate economic evaluation, but it is realistic. To think that private enterprise would voluntarily include socio-economic and environmental benefits in their analysis would be idealistic. However, for a government to invest in an integrated logging operation on the basis of "all benefits" is quite possible.

Maximum expected sawlog volume, maximum pulpwood chip and minimum fuelwood chip production are the conditions which would result in the greatest revenue at present price levels. However, even under the most favorable production and market conditions the products' prices would have to increase more than 20% to break even. With poor markets or low level production, the difference between cost and revenue would only increase.

The attempt of this economic evaluation was to establish "reasonable" cost and benefit estimates for "reasonable" operating conditions. This is why, the evaluation was done in the form of model equations; it allows a great many situations to be examined.

CHAPTER 6

CONCLUSION AND FUTURE WORK

The feasibility of the proposed integrated sawlog-pulpwood-fuelwood site in the Bonavista Peninsula is dependent on the relationship between costs and benefits. By applying the costing model to project annual operational costs and by determining the financial gain expected from the sale of the products, it can be seen if the proposal could ever be a viable operation.

If strictly on an economic basis it is found that the establishment of the integrated logging scheme in Bonavista Peninsula is not a viable operation, the proposal could still be implemented if the socio-economic and environmental advantages were considered sufficient to "disallow" the poor financial situation. This cost-effectiveness attitude, however, may not be suitable for this situation since it would be a continuous monetary drain and not a one-time outlay of funds. If feasibility is marginal, the operation could be undertaken on the "hope" that costs could be streamlined and/or revenues increase.

Market conditions play an important role in determining whether or not the proposed scheme is undertaken. Reliability and availability of markets may supersede the cost aspects of the plan. No matter how efficient the operation, if the product can not be sold or can not be sold at an acceptable price, the operation is doomed to fail.

One on the first steps in the decision-making process once the economics of the situation has been evaluated would be to accept the validity on versatility of the costing model. Once this is done, break-even points corresponding to the expected production characteristics should be determined. Market assessments should also be conducted in order to ensure the disposal of production is adequately examined.

Feedback of information pertaining to aspects of the integrated logging site may mean alternations to the original proposal. For instance, available information may indicate that the proposal be incorporated into an expanded operation which would involve shipment of wood chips from other areas of the province. This expansion may mean an improved economic situation for the use of barge and tug as the transportation mode to market.

The present harvesting practices are detrimental to the Bonavista Peninsula forest stands; but, to the author's knowledge, there is no contingency plan in the offing to correct the situation. This thesis is an attempt to evaluate an operation which could have alleviated the problems of wastage and under-utilization of the forest resource base. A feasible plan which would give direction to the area's forest industry must give consideration to these two problems.

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APPENDICIES

APPENDIX "A"

FOREST MEASUREMENT CONVERSIONS

Imperial to Metric

1 cord (128 stacked ft.^{3}) = 2.407 m^3 solid wood
Mfbm = 4.7m^3

Metric to Imperial

1 m^3 solid wood = 0.4155 cords (128 stacked ft.^{3})
1 m^3 solid wood = 0.212 Mfbm

Volume to Weight — Weight to Volume
(based on specific gravity of Eastern spruce @ 45% MC)

Volume to Weight	Weight to Volume
1 green tonne = 1.9 m^3 solid wood	1 m^3 solid wood = 0.522 green tonnes
1 bone dry tonne = 2.8 m^3 solid wood	1 m^3 solid wood = 0.36 bone dry tonnes

Conversion Calculations

- conversion of Eastern spruce green volume to green weight based on 45% MC

specific gravity of green Eastern spruce wood = G_g = 0.36
density of water = D_W = 1.0 tonne/m^3

green volume = 1.0 M^3 (ie. density calculation implies unity for volume)

moisture content = MC = 45%

oven dry weight = W_0

green weight = W_{45}

$G_g = \frac{W_0}{V_g D_w}$ definition of specific gravity

$\Rightarrow W_0 = G_g V_g D_w$

$W_{45} = W_0\ (1 + MC/100) = G_g V_g D_w\ (1 + MC/100)$

$\Rightarrow W_{45}/_{V_g} = G_g\ D_w\ (1 + MC/100)$

$= (0.36)(1.0\ \text{tonne/m}^3)(1.45)$

$= 0.522$ green tonnes/m^3 solid green wood

- conversion of Eastern spruce green volume to bone dry weight.

$W_o/_{V_g} = G_g\ D_w$

$= (0.36)(1\ \text{tonne/m}^3)$

$= 0.36$ bone dry tonnes/m^3 solid green wood

APPENDIX "B"

CALCULATION OF TRUCK CAPACITY OF A 5-AXLE TRACTOR-TRAILER UNIT EQUIPPED WITH A LOADER

5-axle truck-trailer unit

35,000 kg	Maximum allowable gross vehicle weight
11,400 kg	Tare weight (including loader)
23,600 kg	Payload

payload maximum capacity

= 23.6 tonnes
= 45.0 m^3 solid wood @ 45% MC
= 9.54 Mfbm

APPENDIX "C"

Testing of procurement and processing:

Case #1 Whole-tree Harvesting in Prince Edward Island

Study duration: 9 days

production information:
fuelwood chips = 473.56 green tons @ 42% MC
sawlogs (stud wood) = 44.45 cords

total cost of operation = $10,059

straight-line extrapolation for 200 day operation

production
fuelwood chips = 10,524 green tons (18,720 m^3)
sawlogs = 987.8 cords (503.8 Mfbm)

total cost = $223,422

application of model equations C(1) and C(2)

- delivered wood taken as tree-length
- time value of money i = 10%; n = 20 yrs (for CRF)

∴ SW = 0
TL = 21,090
R = 0
CRF = 0.11746
P = 0
F = 9567

C(1) = 22.78 (21,090)	$480,430
C(2) = 340,000 (0.11746) + 1.25(9567) + 126,200 =	$117,890
	$598,320

time adjusted cost of extrapolation

Compound Amount Factor
i = 10%; n - 3 for 1977-1980
($223,422)(1.3310) = $297,375
i = 15%; n = 2 for 1980-1982
($297,375)(1.3225) = $393,280

Case #2 Trial 1 - Integrated Logging for production of Pulpwood and Hog Fuel

study duration: 11 days

production information:
fuelwood chips = 1887 green tonnes @ 45% MC

total cost of operation = \$71,139

straight-line extrapolation for 200 day operation

production
fuelwood chips = 34,309 green tonnes (65,980 m^3)

total cost = \$1,293,440

application of model equations C(1) and C(2)

- delivered wood taken as tree-length
- time value of money i = 10%; n = 20 yrs (for CRF)

$$\therefore \begin{aligned} SW &= 0 \\ TL &= 65,980 \\ R &= 0 \\ CRF &= 0.117416 \\ P &= 0 \\ F &= 34,309 \end{aligned}$$

C(1) = 22.78 (65,980 = \$1,503,025

C(2) = 39,936 + 1.25(34,309) + 126,200 = \$ 209,020

\$1,712,045

time adjusted cost of extrapolation

Compound Amount Factor
i = 15%; n = 2 for 1980-1982
(\$1,293,440)(1.3225) = \$1,710,575

Case #3 Table 2 - Integrated Logging for Production of Pulpwood and Hog Fuel

study duration: 22 days

production information:
fuelwood chips = 3164 green tonnes @ 45% MC
pulpwood roundwood = 207 m^3
sawlogs = 28 Mfbm

total cost of operation = \$77,961

<u>straight-line extrapolation for 200 day operation</u>

production
  fuelwood chips = 28,764 green tonnes (55,315 m^3)
  pulpwood roundwood = 1882 m^3
  sawlogs = 254.5 Mfbm (1196 m^3)

total cost = \$708,736

<u>application of model equations C(1) and C(2)</u>

- delivered fuelwood taken as tree-length
- delivered pulpwood and sawlogs were in shortwood form

∴ SN = 3078
TL = 55,315
R = 0
CRF = 0.11746
P = 0
F = 28,764

note: although pulpwood was produced, it was in the form of roundwood and the variable pulpwood processing cost deals with the specifics of chipping pulpwood.

C(1) = 22.78 (55,315) +25.55(3078) = \$1,338,720

C(2) = 39936 + 1.25 (28,764) + 126,200 = \$ 202,090

\$1,540,810

<u>time adjusted cost of extrapolation</u>

Compound Amount Factor
  i = 15%; n = 2 for 1980-1982
  (\$708,736)(1.3225) = \$937,304

Testing of product transportation:

<u>Marine</u>: 1 barge - 1 tug operation

information:
  quantity shipped = 30,000 cords (25,920 bone dry tonnes)
  distance of shipment = 160 nautical miles

total cost = \$1,860,600

time adjusted cost: Compound Amount Factor @ i = 15%; n = 2

($1,860,600)(1.3225) = $2,460,640

application of model equation C(3)

S = 0
P = 25,920
F = 0
marine ► T = 15.04
K = 372,400

C(3) = (15.04) 1.45 (25,920) + 372,400 = $937,660

Rail

cost = $1.32/km/carload

projected cost @ chip production of 37,500 green tonnes

$$= \frac{(\$1.32/\text{km/carload})(245\ \text{km})(37{,}500\ \text{tonnes})}{25\ \text{tonnes/carload}}$$

= $485,100

time adjusted cost:Compound Amount Factor @ i = 15%; n = 2

($485,100)(1.3225) = $641,545

application of model equation C(3)

S = 0
P = 0
F = 37,500
rail ► T = 19.44
K = 68,800

C(3) = (19.44)(37,500) + 68,800 = $797,800

Road #1 CTC study

cost = $0.90/km/carload

projected cost # chip production of 37,500 green tonnes

$$= \frac{(0.90/\text{km/carload})(245\ \text{km})(37{,}500\ \text{tonnes})}{25\ \text{tonnes/carload}}$$

= $330,750

time adjusted cost: Compound Amount Factor @ i = 15%; n = 2
($330,750)(1.3225) = $437,417

application of model equation C(3)

S = 0
P = 0
F = 37,500
road ► T = 17.42
K = 0

C(3) = (17.42)(37,500) = $653,250

Road #2 User survey

Cost = $1.15/km/carload

projected cost @ chip production of 37,500 green tonnes

$$= \frac{(\$1.15/\text{km/carload})(245\ \text{km})(37{,}500)\ \text{tonnes}}{25\ \text{tonnes/carload}}$$

= $422,625

time adjusted cost: Compound Amount Factor @ i = 15%; n = 2
($422,625)(1.3225) = $558,922

application of model equation C(3)

S = 0
P = 0
F = 37,500
road ► T = 17.42
K = 0

C(3) = (17.42)(37,500) = $653,250