Terrace Community Forest Timber Supply Analysis Updated Data Package

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Acronyms and Abbreviations

AAC	Allowable Annual Cut
BA	Balsam
BC	British Columbia
BCLCS	British Columbia Land Cover Classification Scheme
BEC	Biogeoclimatic Ecosystem Classification
CFA	Community Forest Agreement
CFLB	Crown Forested Landbase
CC	Clear Cut
CF	Community Forest
CFA	Community Forest Agreement
CFLB	Crown Forested Landbase
CT	Commercial Thinning
CWH	Coastal Western Hemlock
DBH	Diameter at Breast Height
FIP	Forest Inventory Planning
FWA	Fresh Water Atlas
GIS	Geographic Information Systems
GSD	Ground Sampling Distance
Ha	Hectares
HW	Western Hemlock
ICH	Interior Cedar – Hemlock
IRM	Integrated Resource Management
LIDAR	Light Detection and Ranging
LRDW	Land and Resource Data Warehouse
LRMP	Land and Resource Management Plan
MOF	Ministry of Forests
MFLNRO	Ministry of Forests, Lands and Natural Resource Operations
MH	Mountain Hemlock
MHA	Minimum Harvest Age
NHLB	Non-Timber Harvesting Landbase
OAF	Operational Adjustment Factor
OGMA	Old Growth Management Areas
P2P	Plan to Perspective Ratio
PCT	Pre-commercial Thinning
PSPL	Provincial Site Productivity Layer
PR	Partial Retention VQO Classification
REHAB	Rehabilitation
RESULTS	Reporting Silviculture Updates and Status Tracking System
RMZ	Resource Management Zone
RTL	Roads, Trails and Landings
SIA	Site Index Adjustment
SIBEC	Site Index Biogeoclimatic Ecosystem Classification
SPH	Stems per Hectare
SRMP	Sustainable Resource Management Plan
TASS	Tree and Stand Simulator
TCF	Terrace Community Forest
THLB	Timber Harvesting Landbase
TIPSY	Table Interpolation Program for Stand Yields
TRIM	Terrestrial Resources Inventory Mapping
TSA	Timber Supply Area
TSM	Terrain Stability Mapping
TSR	Timber Supply Review
UWR	Ungulate Winter Range
VAC	Visual Absorption Capability
VDYP	Variable Density Yield Prediction Growth and Yield Model
VEG	Visually Effective Green-up Height
VLI	Visual Landscape Inventory
VQO	Visual Quality Objectives
VRI	Vegetation Resources Inventory
WHA	Wildlife Habitat Area
WTP	Wildlife Tree Patch

1. Introduction

The Terrace Community Forest (TCF) covers 25,163 ha of land within the Kalum timber supply area (TSA) in northwestern British Columbia. The Kalum TSA's allowable annual cut (AAC) was set to 424,000 m^3 per year in 2011 and currently, the TCF has an AAC of 30,000 m^3 per year.

The community holds a long-term Community Forest Agreement (CFA) with exclusive rights to harvest crown timber within the area. It is divided into three parcels situated north (Deep Creek), west (Shames) and south (Kitimat) of the community of Terrace (Figure 1-1).

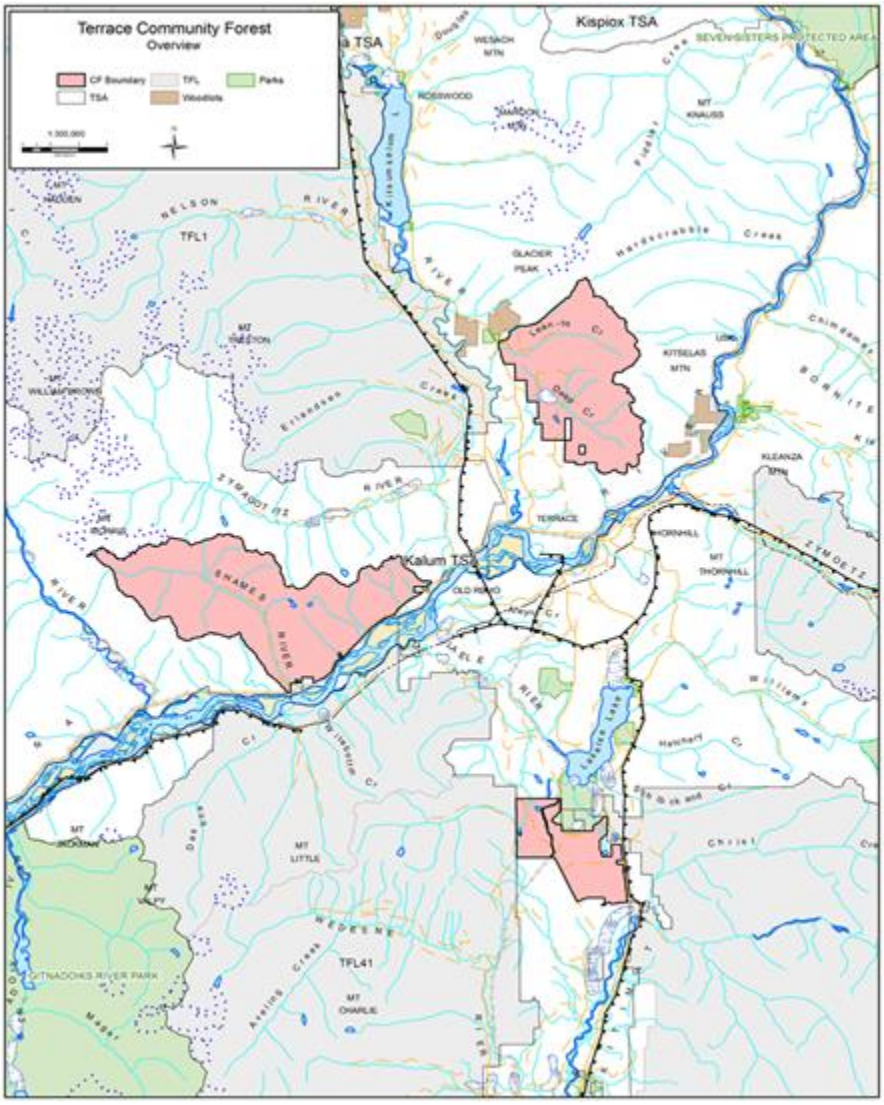

Figure 1-1: TCF Overview

TCF initiated a timber supply analysis project to assist in determining a new AAC. Ecora Engineering & Resource Group Ltd. (Ecora) has been retained by TCF to prepare the information for the timber supply analysis and AAC determination. The purpose of this data package is to document the information sources and assumptions that will guide the development of the timber supply analysis and to discuss potential sensitivity analysis scenarios.

Specifically, this data package documents the information sources and assumptions to be used in the landbase classification for the base case timber supply analysis. The assumptions used are based on the most recent *Kalum TSA Timber Supply Review Data Package* (Kalum Data Package*)* (MFLNRO, 2010), *Kalum Land and Resource Management Plan* (Kalum LRMP) (MFLNRO, 2002), Kalum *Sustainable Resource Management Plan* (Kalum SRMP) (MFLNRO, 2006) and the current management objectives for the community forest.

The TCF has recently improved the data available for the landbase for both timber and non-timber objectives by completing a Vegetation Resource Inventory (VRI) in 2014, a silviculture update in 2016, a geographic information systems (GIS) road classification exercise in 2016, a stream classification exercise in 2016, and a site index adjustment (SIA) project in 2018. These projects contribute to reducing uncertainty and improving the accuracy of the data that will be used for timber supply analysis. These improvements include:

- Completely remapped timber types and non-timber land covers with comprehensive attribute descriptions for all polygons;
- Polygon size that better supports timber supply analysis and operational planning when compared to a TSA level VRI; and
- Site index values that better reflect the growing capacity of the land.

There were some issues identified during the Timber Supply Review (TSR) and the Silviculture Type 2 process in the Kalum TSA Timber Supply Analysis and Type 2 Silviculture Strategy, including:

1. An uneven age class distribution with the majority of the TSA in age classes 8 and 9 and in age classes 1 and 2, and
2. Inaccurate site index and site index by biogeoclimatic ecosystem classification (SIBEC) value requiring adjustment for the site indexes in the TSR and silviculture strategy.

Similar to what was found at the TSA level, TCF has identified issues with the SIBEC site index and developed an SIA project to update and improve the managed stand site index values. This project was developed in accordance with the Ministry of Forests, Lands, Natural Resources and Rural Development (MFLNRO) procedures, the results of which can be found in the *Terrace Community Forest Site Index Adjustment Project Final Report* (Ecora, 2018; Appendix 2). When compared to the Provincial Site Productivity Layer (PSPL), the field site index measured through the SIA project is over 11% higher for hemlock (HW) and less than 1% higher for balsam (BA). The site index adjustments are further discussed in section 6, which describes how the adjustments were applied for managed stands.

The TCF was heavily harvested in the 1960s and 1970s. The forest regeneration procedures of the time resulted in many of these stands being overstocked, causing stands to enter stem exclusion early. These stands exhibit limited understory development and reduced diameter crop trees. As a result, the harvest is uneconomical in these stands until they reach over 100 years of age. These stands are therefore identified through a review process and are labelled as REHAB stands through the remainder of the document.

2. Input Data

This section summarizes the data used to support this timber supply review (TSR).

2.1 Spatial Data

Table 2-1 provides a list of input data layers considered in the analysis. Most layers are from the Land and Resource Data Warehouse (LRDW) or developed by Ecora and TCF.

Table 2-1: Data Sources

Description	Source	Vintage
Biogeloclimatic Ecosystem Classification (BEC) v11	LRDW	2018
Community Forest Boundary	CF	2017
Community Watershed	LRDW	2018
Forest Tenure Recreation Sites	LRDW	2018
Forest Tenure Recreation Trails	LRDW	2018
Land Resource Management Plan Legal	LRDW	2018
Land Resource Management Plan NL	LRDW	2018
Landscape Units	LRDW	2016
Old-growth management area (OGMA) Legal	LRDW	2018
OGMA Non-Legal	LRDW	2018
Ownership	LRDW	2018
Results Openings	LRDW	2018
Classified Road	Ecora	2016
Classified Stream	Ecora	2016
Visual Landscape Inventory	LRDW	2016
VRI	Ecora	2016
Wildlife Habitat Area	LRDW	2018
Ungulate Winter Range	LRDW	2018
Natural disturbance types	LRDW	2018
Research installations and growth & yield plots	LRDW	2018
Silviculture treatments (commercial thinning/ shelterwood)	Ecora	2016
Digital Road Atlas	LRDW	2018
Wetlands	LRDW	2018
Lakes	LRDW	2016
Slope	LRDW	2018
Wildlife Tree Patch	LRDW	2018

2.2 Inventory Information

Ecora completed a VRI for TCF in 2014, using 25 cm ground sample distance (GSD) 4-band aerial digital imagery and 2 ppm light detection and ranging (LIDAR) data acquired in 2013. A multi-step polygon delineation process for the entire project area resulted in a total of 1,530 polygons averaging 16.4 ha in size. The average treed polygon size is 14.0 ha. The 2014 VRI project was completed in accordance with the Provincial VRI standards and procedures in effect at the time of contract signing. All 2014 polygon delineation, field calibration planning and polygon attribution were completed in a virtual environment using PurVIEW v.1.2.0.54 softcopy software on an ESRI ArcMap 9.3.1 platform. Seventeen (17) enhanced one-point ground calls and 35 VRI air calls were installed by Ecora field crews in August 2014.

Additional inventory updates to describe silviculture operations were added to the original project in 2015 and 2016 at the request of TCF. The 2015 and 2016 silviculture update projects were completed following the same VRI procedures as the 2014 VRI project for continuity and were completed in a virtual environment using DAT/EM Summit Evolution Lite v.7.1 softcopy software on an ESRI ArcMap 10.2 platform. For additional information on the VRI, see the *Vegetative Resources Inventory for The Terrace Community Forest Final Report* (Ecora, 2016) found in Appendix 1.

2.3 Logging History

Logging history for the analysis is derived from the recently completed VRI, TCF blocks, Reporting Silviculture Updates and Land Status Tracking System (RESULTS) and consolidated cutblocks data sets. The end date of the harvest operation is used when available, and if it is not available the harvest start date is used. Harvest history has been updated to the end of 2018, and the model start date is January 1, 2019.

3. Landbase Classification

The landbase classification process begins with the total area of TCF and removes the area in a stepwise fashion according to the classification listed in Table 3-1.

Table 3-1: Landbase Classification

Landbase Classification	Gross Area (ha)	Removed Area (ha)
Total area		**22,043**
Non-forest	6,312	6,268
Non-commercial	6,057	14
Road	479	459
Trail	37	14
Crown forested landbase (CFLB)		**15,288**
Wetland	74	28
Lake	119	2
Stream	484	366
Ungulate winter range (UWR)	2,177	1,194
Wildlife habitat area (WHA)	39	0.1
Deciduous	120	82
Low Crown Closure Areas	2,674	787
Low Volume Areas	3,499	658
OGMA	1,282	881
Inoperable	2,876	707
Unstable	1,260	334
Existing WTP	81	73
Future roads (aspatial)		49
Timber harvesting landbase (THLB)		**10,126**

Through this process, the area is systematically removed in order to establish both the crown forested landbase (CFLB) and timber harvesting landbase (THLB). The CFLB is the forested land that contributes towards meeting non-timber objectives, whereas the THLB is defined as the area available for harvest. The landbase classification process classifies the area into three broad categories:

- **Non-Productive**: areas that are not managed by TCF for forest values, non-forested and non-productive (unable to grow viable timber);
- **Productive Non-THLB or CFLB**: productive treed areas that are unlikely to be harvested for reasons such as inoperability or special environmental protection; and
- **THLB**: productive landbase that is expected to be available for timber harvest over the long term.

3.1 Total Area

The total area of TCF is 22,043 ha. The Shames Ski area, which is not managed by the TCF, is excluded from the total area.

The British Columbia Land Cover Classification Scheme (BCLCS) and VRI are used to identify areas that are not forested, such as rock and water, as well as vegetated but non-treed polygons. Non-forested and non-productive polygons as described in Table 3-2 are not part of the CFLB. Areas with a logging history are assumed to be forested or capable of supporting a forested stand and are therefore not removed from the CFLB.

Table 3-2: Non-Forest and Non-Productive Land

BCLCS	Description	Reduction Percent	Reduction Category	Gross Area (ha)	Removed Area (ha)
Level 1 = N	Non-vegetated	100%	Non-Forest	353	353
Level 2 = N and Level 3 = W	Non-treed wetlands	100%	Non-Forest	43	43
Level 2 = N and Level 4 <> ST or SL	Vegetated but non-treed, excluding shrub areas	100%	Non-Forest	5,916	5,872
Level 3 = A	Alpine	100%	Non-Productive	2,610	0

3.2 Roads, Trails and Landings

Ecora completed a geographic information systems (GIS) road classification exercise for TCF in 2016. Roads were classified with publicly accessible government datasets and our best available knowledge. All data layers were downloaded from the LRDW in 2015. Forest tenure roads, forest tenure trails, digital road access and terrestrial resource inventory mapping (TRIM) roads data layers were spatially overlaid with the TCF boundary, then grouped into road, trails and landings (RTLs) inventory classes, which include main, operational, spur and trails. Any roads missing from the dataset (there were very few) were delineated in stereo and assigned RTLs inventory classes at the same time. A list of involved data layers and grouping methods are summarized in Table 3-3. Road buffer widths were then drawn from the average width and removed from the CFLB. There are four types of roads identified in TCF, and their average buffer widths are listed in Table 3-4. RTLs are not forested, hence not part of the CFLB. Existing roads and trails occupy 479 ha, and another 50 ha were aspatially removed from the THLB to account for future roads.

Table 3-3: Road Classification Methods

Road Classification Type	Data Source Layer	Road Class
Main	Forest Tenure Roads	Forest Service Roads
	Digital Road Atlas	Main
		Highway
		Ferry
	TRIM Roads	Resource Road (2 Lanes)
		Resource Road (Paved divided)
Operational	Forest Tenure Roads	Road Permit
	Digital Road Atlas	Local
		Resource Road
		Local (Lane)
		Local (Ramp)
		Local (Restricted)
		Local (Service)
		Local (Strata)
	TRIM Roads	Resource Road (1 Lane)
Spur	TRIM Roads	Resource Road (Unimproved)
		Trail
Trail	Forest Tenure Trails	Trails
	Digital Road Atlas	Trail (Recreation)
		Trail
	Trim Roads	Trail (Cattle Trail)

Table 3-4: Road Buffer Width

Road Classification Type	Buffer Width (m)
Trail	5
Spur	10.0
Operational	10.0
Main	15.0

3.3 Non-Commercial Cover

Non-commercial areas are generally covered by brush species and are also not considered suitable for timber production. All of these areas are excluded from both the CFLB and the THLB as they do not contribute to objectives for wildlife habitat or biodiversity. Non-commercial areas are identified as described in Table 3-5. Areas with a logging history are assumed to be forested or capable of supporting a forested stand and therefore are not removed from the CFLB.

Table 3-5: Non-Commercial Cover

BCLCS	Description	Reduction Percent	Reduction Category	Area (ha)	Removed Area (ha)
Level 2 = T and Level 3 = W and no logging history	Treed wetlands	100%	Non-Commercial	14	14
Level 4 = ST or SL and no logging history	Shrub and not already logged	100%	Non-Forested	3,432	0
Non-forest descriptor is Non-commercial brush and without logging history	Forest Investment Program (FIP) non-commercial, and not already logged	100%	Non-Commercial	1	0

3.4 Crown Forested Landbase

With non-productive, non-forested areas and existing RTL removed from the TCF, 15, 288 ha remain in the CFLB. This is the area that supports tree growth and can contribute to meet non-timber objectives for seral-stage distribution, visual quality objectives (VQOs), integrated resource management and wildlife habitat requirements.

3.5 Riparian Areas

Ecora completed a stream classification exercise for TCF in 2016. Streams, lakes and wetlands were classified with publicly accessible government datasets and to our best available knowledge. All data layers were downloaded from LRDW in 2015. The datasets used in this process, classification criteria and applied buffer widths are listed in Table 3-6.

The Riparian Management Zone (RMZ) is added to the buffer width based on the required percentage. For example, the reserve zone for an S2 stream is 100% of 30 meters and the management zone is 20% of 20 meters. Therefore, the total buffer width applied to an S2 stream is 34 meters on each side. Riparian areas are excluded from THLB.

Table 3-6: Riparian Classification Methods and Buffer Width

Feature	Riparian Class	Reserve Zone (m)	Reserve Zone Reduction (%)	Management Zone (m)	Management Zone Reduction (%)	Riparian Buffer Applied (m)
Rivers and Streams	S1-B	50	100	20	20	54
	S2	30	100	20	20	34
	S3	20	100	20	20	24
Lakes	L1-B	10	100	0	NA	10
	L3	0	100	30	10	3
Wetlands	W1	10	100	40	10	14
	W3	0	100	30	10	3

3.6 Ungulate Winter Range

Ungulate Winter Range (UWR) 6-001 is found in the Deep Creek and Shames parcels of TCF, and UWR 6-009 borders the eastern edge of Shames and the northern edge of Kitimat. The two UWR orders occupy a total of 2,177 hectares of the TCF landbase. All the area of UWR 6-001 within the TCF is classified as a “no harvest zone” and is removed from the THLB. The UWR 6-009 area located in the TCF is classified as a "conditional harvest zone" according to the UWR order (Ministry of Environment, 2004). A 30% aspatial reduction is applied to the conditional harvest zone following the UWR 6-009 legal order. As shown in Table 3-7, only 1,140 hectares from UWR 6-001 and 54 hectares from UWR 6-009 are removed from THLB because it overlaps with previous netdown steps.

Table 3-7: Ungulate Winter Range

UWR Number	Harvest Requirement	Area (ha)	Removed Area (ha)
u-6-001	NO HARVEST ZONE	1,933	1140
u-6-009	CONDITIONAL HARVEST ZONE	244	54

3.7 Wildlife Habitat Area

There are two Wildlife Habitat Area (WHA) orders in the TCF landbase: Coastal Tailed Frog, and Kalum WHA (9-287). The two WHA areas account for 39 ha within the TCF, where only 1 hectare is mapped as not available for harvest and therefore removed from the THLB. A 70% aspatial reduction is applied to the conditional harvest zone of the Coastal Tailed Frog WHA following the suggestion in the *Kalum Data Package*. WHA order 6-287 is also classified as a conditional harvest zone and addressed in the modelling assumptions in section 4.3 therefore included in the THLB.

3.8 Deciduous Forest Types

Deciduous forest types are not currently utilized or have marginal merchantability. Deciduous-leading stands other than cottonwood-leading are therefore excluded from the THLB. The total area with deciduous leading stands is 120 ha, of which 82 ha are removed in the netdown. Cottonwood-leading stands are left in the THLB but unavailable for 100 years to reflect the current practice of the CF.

3.9 Sites with Low Timber Growing Potential

Sites may have low productivity either because of inherent site factors (nutrient availability, exposure, excessive moisture, etc.) or because they are not fully occupied by commercial tree species. Stands that are physically operable and exceed low site criteria or have marginal merchantability are also considered as low timber growing potential stands. Typically, these stands are intermixed with other stands within the forested landbase. As these stands are not considered to be harvestable, they are removed from the THLB using the criteria listed in Table 3-8.

Table 3-8: Description of Sites with Low Timber Growing Potential

Stand	Current Age (years)	Crown Closure (%)	Current Volume (m^3/ha)	Current Height (m)	Height at Age 200 Years (m)	Volume at Age 200 Years (m^3/ha)	Area (ha)	Removed Area (ha)
All	> 200		< 300	< 19.5			262	121
Coniferous Leading	<= 200				< 19.5	< 250	3,237	537
Cottonwood Leading	<= 200				< 19.5	< 250	0	0
Low crown closure (open-grown)	> 60	0 - 25					2,674	787

3.10 Old Growth Management Areas

Old-growth management areas (OGMAs) are identified and removed from the THLB. There is 1,282 ha of OGMA in the TCF, 881 ha of which are removed in the netdown as landbase class 'OGMA'.

3.11 Inoperability

The operability attribute was grouped into "G", "C" and "I", which respectively defines conventional harvest, cable harvest and inoperable. The three operability categories were identified in TCF based on slope class. The identification criteria are listed in Table 3-9. Areas identified as "I" without a logging history are removed from the THLB.

Table 3-9: Operability Class

Operability Type	Slope (%)	Area (ha)	Removed Area (ha)
G	0-40	10,266	0
C	40-80	8,901	0
I	> 80	2,876	707

3.12 Unstable Terrain

The unstable area is identified in the provincial Terrain Stability Mapping (TSM) layer. TSM data is available on approximately 3,100 ha of the CF. Polygons labelled as 'U', which indicates an unstable terrain, and without a logging history are removed from the THLB using the criteria listed in Table 3-10. Polygons labelled as 'P', which indicates a potentially unstable terrain is left in the THLB.

Table 3-10: Terrain Stability

Slope Stability Class	Area (ha)	Removed Area (ha)
U	1,260	334
P	958	0
BLANK	19,825	0

3.13 Wildlife Tree Patches

The Kalum SRMP establishes an objective to maintain structural diversity in managed stands by retaining wildlife tree patches in each cutblock. Retention amounts are specified by landscape unit and BEC variant. The Kalum SRMP states that wildlife tree patches may be internal or external to a cutblock. Retention outside of cutblocks may overlap with riparian reserves or other areas outside of the THLB.

Wildlife tree patches (WTP) are assumed to contribute toward old forest representation and will not be economic to harvest in the future. Existing WTPs are removed from the THLB.

Table 3-11 below summarizes the estimated THLB impact and the amount of forested area removed from THLB in previous netdown steps in each unit (i.e. removals from CFLB such as riparian zones, existing WTP, UWR/WHA conditional harvest reserve). There are enough forested non-THLB (NHLB) areas to meet the WTP targets in most landscape units except for the CWHws zone in Hot Springs and Kitimat. Given that the current management practice of TCF is mainly focused on the managed stands, the deficit amount of 51 ha can be met by the natural stands in THLB. Detailed discussions can be found in section 4.7 of this document. No further reductions are applied to THLB to account for WTP impact.

Table 3-11: Wildlife Tree Retention Reductions

Landscape Unit	Biogeoclimatic Subzone	Estimated Reduction on THLB (%)	THLB Area (ha)	Target THLB Area (ha)	Forested NHLB (ha)	THLB Natural Stand Area (ha)
Exstew	CWH ws	6	984	59	467	391
Exstew	MH mm	3	239	7	967	225
Hot Springs	CWH ws	7	1,508	106	103	72
Kalum	CWH ws	10	3,437	344	1,545	1229
Kalum	MH mm	5	243	12	637	204
Kitimat	CWH ws	7	1,051	74	25	107
Lakelse	CWH ws	7	266	19	48	28
Nelson - Fiddler	MH mm	2	0	0	70	0
Skeena River Kalum	CWH ws	5	2,115	106	984	1,270

4. Current Forest Management Assumptions

4.1 Forest Cover Constraints

Resource management zones (RMZs) are grouped areas that support non-timber resource requirements. Each RMZ has forest cover objectives which are applied to sub-sets of the landbase. These assumptions are consistent with the Kalum Data Package as well as the Terrace Community Forest Management Plan (TCF, 2010). They are often overlapping and therefore not additive in area. The following RMZs occur in the TCF and are shown in Table 4-1.

Table 4-1: Forest Cover Constraint Summary

Objective	Model Constraint	Applicable Landbase
Community Watersheds	Max 30% area height <= 5 m	CFLB
WHA Conditional Harvest Zone	Min 90% area age >80 years	CFLB
UWR	Min 70% area age >80 years	CFLB
Integrated Resource Management Areas (IRM) Zones	Max 35% area height <= 3 m	THLB
VQOs	Max % area < height (dependent on the slope and visual absorption capacity)	CFLB
Seral distributions	Early: Max % area age < 40 years Mature: Min % area age > 80/120 years Old: Min % area age >250 years Based on landscape unit and BEC variant	CFLB
Silviculture treatment candidates	See section 4.7 and Table 4-7	THLB

4.2 Community Watersheds

The Deep Creek Community Watershed falls within the TCF boundary. The forest cover for community watersheds was set to a maximum of 30% of the area to be less than 5 meters in height, following the *Kalum TSA TSR Updated Data Package* (MFLNRO, 2010). This condition is modelled by only harvesting adjacent harvest blocks when the opening reaches 5 m in height in the community watershed area.

4.3 Wildlife Habitat Area (WHA) Conditional Harvest Area

Harvesting in the conditional harvest area of Kalum WHA follows the requirements in the WHA order 6-287. This is modelled by retaining at least 90% of the conditional harvest area as mature + old forest (age greater than 80) throughout the planning horizon. This is shown in Table 4-2 below.

Table 4-2: Wildlife Habitat Area Conditional Harvest

WHA Name	Harvest Requirement	CFLB Area (ha)
Grizzly Bear 6-287	At least 90% area > age 80	383

4.4 Integrated Resource Management Zones

4Integrated Resource Management Zones (IRM zones) are applied at the landscape unit level consistent with the Kalum TSR. Within each landscape unit, a maximum of 35% may be less than 3 m in height (MFLNRO, 2010). This condition is modelled by only harvesting adjacent harvest blocks when the opening reaches 3 m in height.

4.5 Visual Quality Objectives

To manage the visual impacts of harvesting on crown land, the government delineates and classifies visually sensitive areas for scenic management as part of the visual landscape inventory (VLI). In this timber supply analysis, visual modelling is implemented according to the *Procedures for Factoring Visual Resources into Timber Supply Analyses* (MOF, 1998), and the update *Bulletin Modelling Visuals in TSR III* (MOF, 2003).

Polygons selected to achieve VQOs have been identified in the VLI and have been classified based on their permissible visually effective disturbance level. Within these classifications, categories of visual absorption capacity (VAC) help define the maximum percent alteration allowed on each VLI polygon. This is shown in Table 4-3. A digital elevation model was used to derive an average slope for each VLI polygon. The perspective to plan (P2P) and visually effective green-up (VEG) heights were derived for each VLI polygon based on the values shown in Table 4-4. The VQO percentage (i.e., the maximum percentage of the area has a height lower than VEG height) was determined for each VLI polygon by multiplying the VAC percentage by the P2P ratio.

Table 4-3: VQO Assumptions

VQO Class	% Alteration by VAC (Perspective View)		
	Low	Medium	High
Retention	0.1	0.7	1.5
Partial Retention	1.6	4.3	7.0
Modification	7.1	12.5	18.0

Table 4-4: VQO VEG Height Requirement

Category	Slope Classes (%)														
	0 - 5	6 - 10	11 - 15	16 - 20	21 - 25	26 - 30	31 - 35	36 - 40	41 - 45	46 - 50	51 - 55	56 - 60	61 - 65	66 - 70	71+
P2P	4.68	4.23	3.77	3.41	3.04	2.75	2.45	2.22	1.98	1.79	1.6	1.45	1.29	1.17	1.04
VEG (m)	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	6.5	7.0	7.5	8.0	8.5	8.5	8.5

4.6 Seral Stage Requirements

The early, mature and old seral stage requirements established by the *Kalum SRMP* (MFLNRO, 2006) are listed in

Table 4-5: Seral stage definitions

BEC Variant	Forest Stand Age (Years)		
	Early	Mature	Old
CWH ws1/ws2	<= 40	> 80	> 250
MH mm1/mm2	<= 40	> 120	> 250

Table 4-6 for the landscape units that cover the Terrace CF. Seral stage age definitions by BEC variant are listed in Table 4-5. Old seral stage requirements have been partially implemented by legally established Old Growth Management Areas (OGMAs). They are removed from the THLB as described in Section 3.10. The seral conditions are modelled by only harvesting blocks when the landscape units have enough forest to meet the permissible amount.

Table 4-5: Seral stage definitions

BEC Variant	Forest Stand Age (Years)		
	Early	Mature	Old
CWH ws1/ws2	<= 40	> 80	> 250
MH mm1/mm2	<= 40	> 120	> 250

Table 4-6: Seral Requirements

Landscape Unit	BEC Variant	Early Seral Distribution (%)	Mature+Old Seral Distribution (%)	Old Seral Distribution (%)
Exstew	CWHws1/ws2	<36	>34	>9
	MHmm2	<22	>36	>19
Hot Springs	CWHws1/ws2		>17	>9
Kalum	CWHws1/ws2	<36	>34	>9
	MHmm2	<22	>36	>19
Kitimat	CWHws1/ws2		>17	>9
Lakelse	CWHws1/ws2	<36	>34	>9
Skeena River Kalum	CWHws1/ws2	<27	>51	>13
	MHmm1/mm2	<17	>54	>28

4.7 Current Stand Types

The community forest was heavily harvested from the 1960s through the 1970s which resulted in large areas of dense, naturally regenerated stands. These densely regenerated stands enter stem exclusion early, causing high mortality and a closed canopy. This restricts the understory vegetation, restricts wildlife access, reduces available understory vegetation for wildlife, reduces the diameter growth of the crop trees, and increases fuel build-up. Stands from these areas are identified as REHAB stands. REHAB stands are first chosen through the identification of key stand attributes and harvest history and then refined based on local knowledge. Table 4-7 illustrates the classification criteria of the current stand types on the TCF landbase.

Purpose-driven silviculture spacing and harvesting represent major avenues to affect changes on the forest landscape. The TCF has invested in pre-commercial thinning/commercial thinning operations and analysis of these REHAB stands. Spacing or pre-commercial thinning could mitigate the negative effects that overstocked stands can have on the landbase and harvest flow. These negative effects include high mortality rate due to the lack of available growing space and small diameter logs. Spacing can also set up the stand for a positive return on commercial thinning and clear-cut. If no silviculture treatment occurs for the identified REHAB stands and they are left with their current composition, it will delay their availability for harvest and increase the amount of decay, waste, and breakage associated with harvest. However, the opportunities for silviculture intervention can be limited based on the age of the stand as described in Table 4-7.

Some of these densely regenerated stands were treated with pre-commercial thinning (i.e. juvenile spacing). In order for these stands to be economical for harvest, they need to be commercially thinned in the biological window available. Commercial thinning will allow for improved crop diameter, understory diversity, and wildlife habitat. TCF has extensive regional expertise in the use of silviculture treatments and has completed thinning trials within the TCF.

Kim Haworth (TCF manager) established the Onion Lake Flats Pruning Density Trial, in 1993. The trial area is 171.1 hectares and is located within the CWHws1 Biogeoclimatic subzone. This area was harvested in 1972-73 and regenerated naturally with western hemlock and amabilis fir. The trial consists of 17 different treatment units including a control. The 16 treatments and one control were randomly assigned to the units. Spacing and pruning began in the summer of 1993, and all areas were completed by the spring of 1995. All units, except the control, were thinned to six target density levels (300, 450, 600, 800, 1000, and 1200 stems per ha; SPH). Each thinning density had three regimes:

- Not pruned
- 100% pruned, and
- Every 2nd tree pruned (50% pruned), except for the 300 and 450 SPH densities which did not include a 50% prune regime.

A second lift prune (~6.0 m) was completed between the fall of 2001 and 2004.

The first commercial thinning that took place in the TCF was in 2014/2015 in cutting permit 8 block 1. Cutting permit 8 block 1 is located within the Coastal Western Hemlock (CWH) Biogeoclimatic zone and consists of four openings that were logged between 1971 and 1974. A portion of the block (Opening 103 I 037–007) was broadcast burnt in 1972 and planted shortly thereafter. The remainder of the block was naturally regenerated with hemlock and balsam. The block was juvenile spaced between 1990 and 1997 to approximately 1,200 SPH. This study was established as a baseline for future measurements in order to compare and contrast the growth patterns of trees that remain after commercial thinning harvest entries.

In 2018, 130 ha of the previously spaced areas were commercially thinned to a target density of 400 SPH. The average volume taken from the commercial thinning entry is about 225 m^3/ha, resulting in a return of approximately 29,250 m^3 per year.

Figure 4-1 shows the previous thinning trials being developed. Figure 4-2 shows a site that had previous pre-commercial thinning in the process of being commercially thinned (right side of the photo). Figure 4-3 shows a treatment site in winter.

Figure 4-1: Previous trial treatment implementation (Photo by Jason Bennett)

Figure 4-2: Thinning within TCF (Photo by Jason Bennett)

Figure 4-3: TCF treatment site in winter (Photo by Jason Bennett)

Through these silvicultural treatment trials, the CF has assessed stands that have been commercially thinned and those that have not. Stands that were not commercially thinned between the ages of 30-50 were found to become REHAB candidate stands. If these stands move outside of the biological limit for commercial thinning, the timber becomes uneconomical for 100 years. They are currently harvestable but are undesirable and low priority given their low economic potential.

Table 4-7: Current Stand Conditions

Current Stand Conditions	Criteria					THLB Area (ha)
	Leading Species	Spacing History	Thinning History	Stand Age	Density	
Regular PCT	HW, BA	No	No	<= 25	All	634
Regular CT	HW, BA	Yes	No	<55	All	1,988
		No	No	25 - 55	< 1000	1,064
Low-value CT	HW, BA	No	No	25 -55	>= 1000	1,449
REHAB	HW, BA	Yes	No	>= 55	All	175
		No		50 - 80	>= 1000	76
Treatment CC	HW, BA	All	Yes	All	All	563
Deciduous	All Deciduous	No	No	All	All	159
Natural Treatment Stand	HW, BA	No	No	All	All	2,325
Natural Stand	Other Conifer	No	No	All	All	1,693
Total						**10,126**

5. Modelling Approach

5.1 Forest Estate Model

The spatial analysis will be conducted using the Patchworks spatial optimization model. Patchworks is a spatially explicit harvest scheduling optimization model developed by Spatial Planning Systems in Ontario. It is capable of developing spatially explicit harvest allocations that explore trade-offs between a broad range of conflicting management and harvest goals.

For this analysis, Patchworks will be formulated to maximize harvest volume while meeting all the required management objectives.

Harvest scheduling decisions are based on maximizing the harvest forecast over the long term, subject to meeting non-timber and other management objectives on the landbase. As such, there are no explicit harvest rules other than minimum merchantability limits applied to the model. All scenarios must maintain a sustainable growing stock level in the long term.

The model utilizes 5-year planning periods over a 250-year planning horizon.

5.2 Harvest Flow Objectives

The objective of the analysis is to determine the capacity of the TCF landbase to sustain timber harvesting over time. The scenarios must identify any risks to this flow resulting from uncertainty in the underlying data or assumptions. The analysis goes beyond a simple calculation of capturing the growth potential of the landbase. The biological capacity of the forest to grow trees, as well as non-timber requirements and silviculture systems, dictate the sustainable harvest level for a particular area. There are a number of alternative harvest-flows possible. In this analysis, we will establish a harvest level that best meets the needs of TCF over a 250-year planning horizon and also examine alternative rates of harvest.

5.3 Utilization Levels

The utilization levels are based on the provincial standard and what economic forces require. Diameter at breast height (DBH) of 12.5 cm for pine leading stands and 17.5 cm for all other stands are used to determine gross merchantable volume.

5.4 Minimum Harvest Criteria

Minimum harvest age (MHA) for both existing natural and future managed stands is derived for each analysis unit based on the age at which the stand achieves a specific volume of 250 m^3/ha. This assumption is consistent with the Kalum Data Package.

5.5 Unsalvaged Losses

Unsalvaged losses represent an annual volume of non-recoverable losses of timber due to damage caused by environmental conditions or insects over and above endemic values already captured within the growth and yield models. The unsalvaged loss estimates are calculated based on a pro-rated value from the TSA level figure from the Kalum Data Package (MFLNO, 2010). The Kalum TSA THLB is 80,820 ha (MFLNRO, 2011), and the TCF THLB size is 13% of the Kalum TSA. The unsalvaged loss estimates from Table 5-1 are applied to the results of all timber supply scenarios.

Table 5-1: Unsalvaged Losses

Cause of loss	Kalum TSA Unsalvaged Loss Estimates (m^3/year)	TCF Unsalvaged Loss Estimates (m^3/year)
Fire	2,500	321
Wind damage	2,500	321
Total Annual Loss	**5,000**	**642**

6. Growth and Yield Assumptions

6.1 Natural Stand Yield Tables

Stand attributes from the VRI are used to generate the yield curves for each polygon using the Variable Density Yield Prediction Growth and Yield Model (VDYP) Version 7. These polygon-level yield tables are then carried into the timber supply model. Due to the large number of yield tables produced, it is not feasible to include them in this data package; however, digital versions of the yield tables can be provided.

6.2 Managed Stand Yield Tables

Growth and yield for all recently harvested stands and future regenerated stands will be modelled with the Tree & Stand Simulator (TASS II), which is a well-established, in-house version of the MFLNRO. All managed stand yield tables were ordered by Ecora for The TCF from the MFLNRO Stand Development Modelling group within the Forest Analysis and Inventory Branch.

Growth and yield assumptions for the TCF are shown below through Section 6.2.1 to Section 6.2.3 and Table 6-1 to Table 6-2.

6.2.1 Site Productivity Estimates

Ecora prepared and completed an SIA project for the TCF intending to improve managed stand yield estimates. The process, approach and sample design were approved by MFLNRO. The objective of the SIA was to conduct unbiased field sampling to validate and localize the existing site index values from the PSPL to reflect the growing conditions of the TCF. PSPL estimates the site index of commercial species across BC through the application of SIBEC and SIA data to areas with existing ecosystem maps and developing gap-filling biophysical models. SIA project findings (Ecora, 2018) were applied as adjustment ratios (Table 6-1) to the PSPL site index values. SIA site indexes are used to estimate existing and future managed stand productivity, and the VRI site index is used to estimate natural stand productivity. The area weighted average VRI site index is used for analysis units where PSPL values are not applicable.

The SIA site index values are calculated as PSPL site index values multiplied by the corresponding adjustment ratios in Table 6-1.

Table 6-1: SIA Project Adjustment Ratio

Geographical Units	Species/Site Index (m)	Adjustment Ratio
Deep Creek	HW	1.1747
	BA	1.0700
Kitimat	HW	1.1670
	BA	0.9586
Shames	HW	1.0022
	BA	0.9576

6.2.2 Regeneration Assumption

Regeneration assumption for stands that are not western hemlock and balsam leading follows the species composition assumptions from the Kalum Data Package. Silviculture regime for western hemlock and balsam leading stands are modified to reflect the TCF current management, as shown in Table 6 2. The regeneration assumptions were discussed and reviewed with the TCF manager. All managed stand curves were generated by the growth and yields specialist from MFLRNORD using TASS II.

Table 6-2: Base Case Regeneration Assumptions

Analysis Unit	Regeneration		Site Index		Leading Species		Initial	Regen
	Method	%	PSPL	SIA	Species	%	Density	Delay
All_decid	Natural	100	20.9	20.9	Cottonwood	100	800	1
Ba_g	Natural	100	25.6	25.8	Balsam	100	10,000	2
Ba_m	Natural	100	25	24.2	Balsam	100	10,000	2
Ba_p	Natural	100	21.6	20.7	Balsam	100	10,000	2
Ba_l	Natural	100	5.3	5.5	Balsam	100	10,000	2
Cw_g	Plant	100	21.2	21.2	Cedar	100	2,000	1
Cw_m	Plant	100	22.1	22.1	Cedar	100	2,000	1
Cw_p	Natural	100	20.0	20.0	Cedar	100	2,000	2
Hw_g	Natural	100	22.7	25.6	Western hemlock	100	10,000	2
Hw_m	Natural	100	22.4	25.1	Western hemlock	100	10,000	2
Hw_p	Natural	100	21.8	24.5	Western hemlock	100	10,000	2
Hw_l	Natural	100	20.9	21.4	Western hemlock	100	10,000	2
Hm_m	Natural	100	20.1	20.1	Mountain hemlock	100	4,500	2
Hm_p	Natural	100	18.0	18.0	Mountain hemlock	100	4,500	2
Hm_l	Natural	100	8.5	8.5	Mountain hemlock	100	4,500	2
Pl_g	Plant	100	30.6	30.6	Pine	100	1,400	1
Pl_m	Plant	100	20.4	20.4	Pine	100	1,400	1
Pl_p	Plant	100	15.9	15.9	Pine	100	1,400	1
Sx_g	Plant	100	25.8	25.8	Spruce	100	2,000	1
Sx_m	Plant	100	25.2	25.2	Spruce	100	2,000	1

6.2.3 Silviculture Regime

As described in Section 4.7 and Table 4-7 above, the conventional forest management pathway of the TCF is to PCT at age 20, CT at age 40 and clear-cut after age 80.

Figure 6-1 and Figure 6-2 below illustrate the stand characteristic differences with/without silviculture treatments. The three-path silviculture system mimics the natural thinning (canopy shading) ahead of time and creates a well-spaced stand with fewer trees per hectare but a larger basal area and higher merchantable volume per tree. The CT treatment creates a minor difference in volume but provides early access to timber supply without compromising the long-term sustainable yield and improves the wood quality.

As can be seen from Figure 6-1, stands with no treatment are small in diameter and are delayed in reaching merchantable size when compared to managed stands. These untreated stands are not necessarily low in volume and can be harvested earlier (e.g., after 60 years), but are low value, small diameter wood that are difficult to find a market for. However, if these stands are spaced at age 20 and commercially thinned at about 40, it not only allows early access to the timber but also improves the wood quality at the time of the final entry cut.

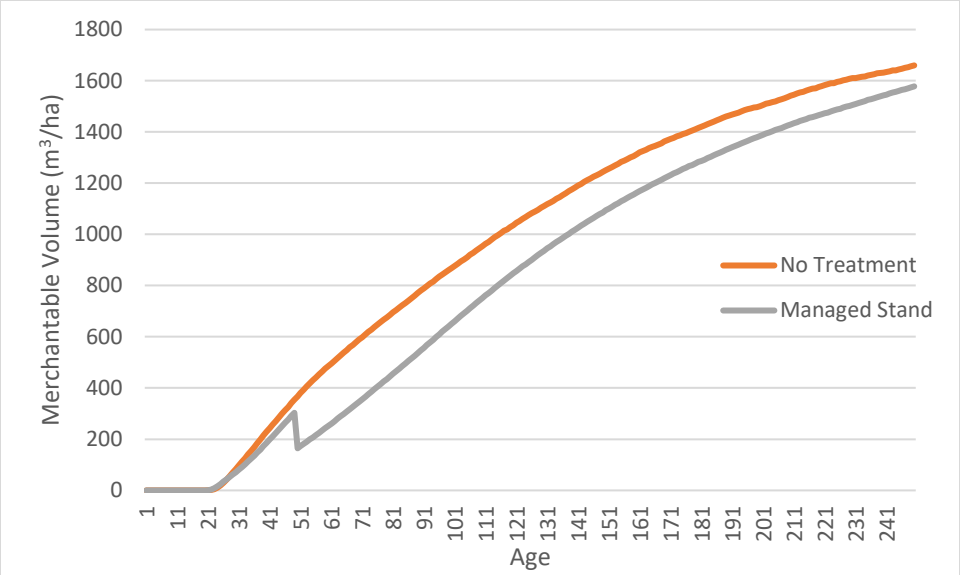

Figure 6-1: Stand Merchantable Volume Comparison

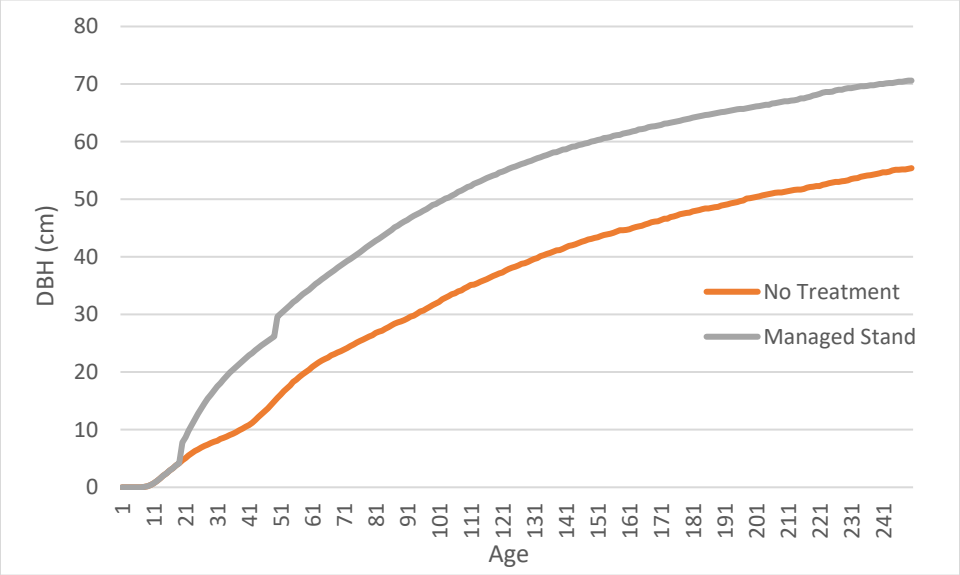

Figure 6-2: Stand Diameter at Breast Height Comparison

The timber supply analysis will assess the impact and risk associated with these stands if not treated. For all managed stands that do not receive silviculture treatment (PCT / CT), harvest is deferred for 100 years, when it is expected that natural thinning will increase their overall value. Base case silviculture treatment regimes and model assumptions for balsam and western hemlock leading stands are listed in Table 6-3 to Table 6-4 below.

Table 6-3: Base Case Silviculture Regime for Balsam and Western Hemlock Leading Stands

Analysis Unit	Regeneration		Site Index		Leading Species		Initial Density	Regen Delay	PCT Age	PCT SPH	CT Age	CT SPH
	Method	%	PSPL	SIA	code	%						
ba_g-no_treatment	Natural	100	25.6	25.8	BA	100	10,000	2				
ba_g-regular_pct	Natural	100	25.6	25.8	BA	100	10,000	2	20	800		
ba_g-regular_ct	Natural	100	25.6	25.8	BA	100	10,000	2	20	800	50	300
ba_g-low_value_ct	Natural	100	25.6	25.8	BA	100	10,000	2			50	300
ba_m-no_treatment	Natural	100	25.0	24.2	BA	100	10,000	2				
ba_m-regular_pct	Natural	100	25.0	24.2	BA	100	10,000	2	20	800		
ba_m-regular_ct	Natural	100	25.0	24.2	BA	100	10,000	2	20	800	50	300
ba_m-low_value_ct	Natural	100	25.0	24.2	BA	100	10,000	2			50	300
hw_g-no_treatment	Natural	100	22.7	25.6	HW	100	10,000	2				
hw_g-regular_pct	Natural	100	22.7	25.6	HW	100	10,000	2	20	800		
hw_g-regular_ct	Natural	100	22.7	25.6	HW	100	10,000	2	20	800	50	300
hw_g-low_value_ct	Natural	100	22.7	25.6	HW	100	10,000	2			50	300
hw_m-no_treatment	Natural	100	22.4	25.1	HW	100	10,000	2				
hw_m-regular_pct	Natural	100	22.4	25.1	HW	100	10,000	2	20	800		
hw_m-regular_ct	Natural	100	22.4	25.1	HW	100	10,000	2	20	800	50	300
hw_m-low_value_ct	Natural	100	20.1	20.1	HW	100	10,000	2			50	300
hw_p-no_treatment	Natural	100	21.8	24.5	HW	100	10,000	2				
hw_p-regular_pct	Natural	100	21.8	24.5	HW	100	10,000	2	20	800		
hw_p-regular_ct	Natural	100	21.8	24.5	HW	100	10,000	2	20	800	50	300
hw_p-low_value_ct	Natural	100	21.8	24.5	HW	100	10,000	2			50	300
hw_l-no_treatment	Natural	100	20.9	21.4	HW	100	10,000	2				
hw_l-regular_pct	Natural	100	20.9	21.4	HW	100	10,000	2	20	800		
hw_l-regular_ct	Natural	100	20.9	21.4	HW	100	10,000	2	20	800	50	300
hw_l-low_value_ct	Natural	100	20.9	21.4	HW	100	10,000	2			50	300

Table 6-4: Silviculture Treatment Base Case Model Assumptions

Stand Types	Model Treatment	Model Treatment Age	Candidate AU
Regular PCT	PCT	15 – 25	*-regular_pct
	CC	Defer for 100 years	
Regular CT	CT	35 – 55	*-regular_ct
	CC	Defer for 100 years	
Low-value CT	CT	35 – 55	*-low_value_ct
	CC	Defer for 100 years	
REHAB	CC	Defer for 100 years	*-rehab[1]
Treatment CC	CC	Above MHA	All stands that have either received PCT + CT treatments
Deciduous	CC	Defer for 100 years	All_decid
Natural Treatment Stand	CC (first rotation)	Above MHA	All HW, BA leading stands Ba_*, Hw_*
	PCT => CT => CC (second rotation +)	15 – 25 => 35 – 55 => > 80	
Natural Stand	CC	Above MHA	Other Conifer leading stands Hm_*, Pl_*, Sx_*

6.3 Operational Adjustment Factors

Operational adjustment factors (OAFs) are applied to all managed stand yield curves modelled in TIPSY. OAF 1 is 15%, and OAF 2 is 5%.

[1] Post REHAB treatment curve is modelled as 35% of the original curve.

7. Sensitivity Analysis

Sensitivity analyses help quantify the degree to which uncertainty in the analysis might affect the resulting timber supply for the landbase. The sensitivities listed in Table 7-1 are considered in the analysis. This list may be refined in consultation with TCF and other stakeholders as the analysis are conducted.

Table 7-1: Potential Sensitivity Analysis Scenarios

Sensitivity	Range Tested	Scenarios
MHA	Assess the impacts of determining MHA	Increase the minimum harvestable volume
		Decrease the minimum harvestable volume
Yield Assumption	Increase/decrease both managed and natural stand yields	Natural Stand Yield Tables +/- 10%
		Managed Stand Yield Tables +/- 10%
		Managed Stand Yield Tables + 30%
Cutblock Size	Limit undersized cutblocks < 5ha	To assess the impact of limiting small cutblocks
Removal of SIA	Assess the impact on managed stands of removing the site index adjustment for hemlock and balsam	The use of the site productivity layer for managed stands
REHAB Treatment	Apply REHAB treatment to candidate stands	To assess the impact of rehab treatment on the candidate stands
No silviculture Treatment	Change the availability of spacing treatment to stands identified in Section 4.7	To assess the impact of no Commercial thinning/ thinning on the long-term harvest level
Budget Maximum Silviculture Scenario	This allows the model to better represent where optimal treatments should go based on a fixed budget.	Limited budget pre-commercial thinning of $300,000 per 5 years at $2,200 per hectare

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Appendix 1

Vegetation Resource Inventory for the Terrace Community Forest Final Report

Appendix 2

Terrace Community Forest Site Index Adjustment Project – Final Report