Nass Timber Supply Area

Vegetation Resources Inventory

Strategic Inventory Plan

PREPARED BY:

NASS TSA STAKEHOLDERS COMMITTEE

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Timberline
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EXECUTIVE SUMMARY

This Vegetation Resources Inventory (VRI) Strategic Inventory Plan (VSIP) outlines the VRI activities and products that address the forest management and inventory issues in the Nass Timber Supply Area (TSA). The stakeholders for this project include West Fraser Mills Ltd., Canada Resurgence Development Corporation, Sim Gan Forest Group, BC Timber Sales and the Ministry of Forests and Range (Forest Analysis and Inventory Branch and Northern Interior Forest Region).

This VSIP was prepared by the Nass TSA stakeholders. The stakeholder group should review this VSIP prior to developing the VRI Project Implementation Plan (VPIP) for Phase I and Phase II programs to ensure these are consistent with their business needs.

The priority forest management issues identified by stakeholders are to:

1. Replace the current forest inventory with one that better reflects the information needs of the stakeholders.[1,2] The Nass TSA licensees lack lost faith in the quality of the information derived from the inventory and have not used it operationally for many years. The reason for this is that the inventory is old and unreliable. The majority of the inventory is over 17 years old, and approximately one-third of it is more than 30 years old. The inventory was built to earlier standards that likely produced large polygons with unreliable boundaries and inaccurate attribute estimates.
2. Address the merchantability of western hemlock on the TSA and upgrade the forest cover information to current VRI standards. Studies in the adjacent Kalum TSA indicate taper is overestimating volume, loss factors are missing decay, and conk and blind conk affected trees are yielding more volume than estimates predict.

The following VRI activities and products are planned:

1. Conduct a softcopy Phase I VRI photo-interpretation (starting in 2007), over the entire Nass TSA (excluding the Nisga'a First Nations area that falls within the Nass TSA). The VRI Phase I will support timber-emphasis inventories, vegetation mapping, habitat mapping, riparian mapping, and other inventory applications.
2. Assess and update the TRIM II base mapping for the Nass TSA concurrently with the VRI Phase I for road and trail reclassification as required.
3. Install approximately 75 Phase II VRI timber emphasis ground plots in polygons greater than 30 years in the operable portion of the vegetated treed (VT) land base of the Nass TSA to provide statistically valid timber volumes and polygon-specific tree attributes. This may follow a two-stage approach. The intent will be to achieve a target sampling error of ±10% at a 95% confidence level.

[1] Note that the inventory audit showed that there was no statistical difference between the inventory and ground volumes for the both the forested and operable land bases

[2] A Pre-inventory Analysis of the existing inventory may better quantify the specific weaknesses with the current polygon boundary and associated attributes. This should be completed prior to beginning a VRI Phase I program.

4. Complete Net Volume Adjustment Factor (NVAF) destructive sampling on the VT area of the Nass TSA to provide statistically valid and localized decay factors for the TSA.
5. Consider implementing a Change Monitoring Inventory (CMI) to provide improved information on the growth & yield performance of second growth stands.

The VRI Phase I and Phase II/NVAF VPIPs will be completed following discussion and approval of this VSIP. Next, a Pre-inventory Assessment should be completed on the existing inventory to better quantify the specific attributes that are inaccurate. Assuming approval of both programs, the VPIPs will provide details for implementation of VRI photo-interpretation and ground sampling in terms of geographic areas, scheduling, priorities, plot location coordination, estimated inventory costs by year, and roles and responsibilities. The Phase II VRI/NVAF VPIP will most likely be completed once the Phase I VRI program is complete.

The proposed cost for developing a new inventory in the Nass TSA is $2,500,000. This includes the cost of re-flying the 2001 photo area (south of Bowser Lake, or 970,000 ha) and smaller portions of the 2003 photo area (north of Bowser Lake) that are not currently suitable for use in Phase I VRI.

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1.0 INTRODUCTION

1.1 Background

This Vegetation Resources Inventory (VRI) Strategic Inventory Plan (VSIP) outlines VRI activities and products needed to address forest management and inventory issues in the Nass Timber Supply Area (TSA). The VSIP provides details for photo interpretation, ground sampling, and statistical adjustment of the inventory. Following VSIP approval, the next steps include preparation of VRI project implementation plans (VPIP) based on this VSIP, and implementation of the VPIPs.

The Nass TSA stakeholders group is comprised of participants operating within the Kalum Forest District, including Skeena Sawmills Ltd. – a division of West Fraser Mills Ltd., BC Timber Sales (BCTS) and the Ministry of Forests and Range (MoFR) represented by the Kalum Forest District, the Northern Interior Forest Region, and the Forest Analysis and Inventory Branch. The stakeholders are as follows:

- MoFR
- BCTS
- Ministry of Environment
- BC Parks
- West Fraser Mills Ltd.
- First Nations
- Canada Resurgence Development Corp.
- Sim Gan Forest Corp. managed by Interpac

This VSIP follows a conference call with stakeholders that took place on September 26, 2006 in Terrace, BC. The following is a list of attendees for this meeting:

- Kim Haworth (Kingfisher Forest Sciences Co. Inc.)
- George Burns (MoFR – Kalum)
- Damian Keating (West Fraser Mills)
- Gail Campbell (BCTS)
- Sam Otukol (MoFR – Victoria)
- Gary Johansen (MoFR – Victoria)
- Will Smith (MoFR – Victoria)
- Dick Nakatsu (MoFR – PG)
- Laurence Bowdige (MoFR – Victoria)
- Mike Sandvoss (Timberline Natural Resource Group Ltd.)
- Hamish Robertson (Timberline Natural Resource Group Ltd)
- Hugh Carter (Timberline Natural Resource Group Ltd)

1.2 VRI Overview

The VRI is a vegetation inventory process that has been approved by the former Resources Inventory Committee (RIC) to assess the quantity and quality of BC's timber and vegetation resources. The VRI estimates overall population totals and averages, as well as individual polygon attributes, for timber and non-timber resources. Its design is simple, reasonably efficient,

statistically defensible, and addresses issues raised by the Forest Resources Commission in its 1991 report, *The Future of Our Forests*.[3]

The VRI consists of several components[4]:

1. Photo Interpreted Estimates (Phase I).
2. Ground Sampling (Phase II) – timber emphasis, ecology, coarse woody debris.
3. Net Volume Adjustment Factor (NVAF) sampling.
4. Change Monitoring Inventory (CMI).
5. Statistical Adjustment.

One or more of these components can address specific forest management or inventory issues. For more detailed information, VRI manuals are available on the MoFR – Forest Analysis and Inventory Branch website.[5]

1.3 VRI Planning

The VRI planning process requires that a VSIP and VPIP be developed for defined units (e.g. TSA, Tree Farm Licence [TFL]). A VSIP outlines VRI products to address forest management issues and provides strategic direction for implementing the inventory activities. A VPIP details the operational activities identified in the VSIP (e.g., ground sampling or photo interpretation projects) and identifies project areas, priorities, and roles and responsibilities.

The VRI planning process is an important component of the overall VRI process and related activities (Figure 1). The intent is to ensure that baseline products meet a range of applications and are efficiently implemented. These processes and activities include:

1. Forest management decision processes (land integration planning);[6]
2. All agencies and stakeholders meet to explain and specify issues and to determine how VRI activities may assist in resolving issues;
3. VRI Strategic planning (prepare a VSIP);
4. VRI operational planning (prepare VPIP); and
5. Implementation, including development and maintenance of procedures and standards:
    a. Management inventories;
    b. Database management;
    c. Data interpretation.

The steps for preparing a VSIP include:

[3] Forest Resources Commission. 1991. The Future of Our Forests – Executive Summary. Unpublished, Victoria. 41 pp.

[4] A glossary of technical terms is provided in Appendix I.

[5] http://www.for.gov.bc.ca/hts/vri/

[6] The Nass TSA Sustainable Resource Management Plan (SRMP) is ongoing at this time.

1. Licencee stakeholders work with MoFR staff to develop issue statements related to the VRI.
2. All agencies and stakeholders meet to refine issues and discuss why these issues need to be considered fundable. The purpose of this meeting is to:
    a. Introduce the VRI tools and process;
    b. Identify new issues and address existing ones;
    c. Discuss issues that can be funded or not (under current funding mechanisms); this discussion provides general direction for developing the VSIP. This discussion also affects the extent of photo interpretation and the number and type of VRI plots.
    d. Suggest the VRI tools to address currently fundable issues as well as those issues that may be funded in the future.
3. Meeting minutes are prepared and circulated to all participants for review and feedback.
4. A final VSIP is prepared. This VSIP incorporates items agreed to in Step 2 and 3 and is signed off by committee members.
5. VPIP process begins.

The VPIP details the activities identified under the VSIP (Phase I Photo Interpretation or Phase II Ground Sampling) by providing project areas; priorities; scheduling; identifying the population and strata for sampling; and sample size. The steps for preparing the VRI Phase I & Phase II/NVAF VPIPs include:

1. Review and update VSIP recommendations.
2. Secure funding.
3. Identify project activities, geographic areas, and costs.
4. Specify roles and responsibilities for project implementation.
5. Prepare the VPIP.

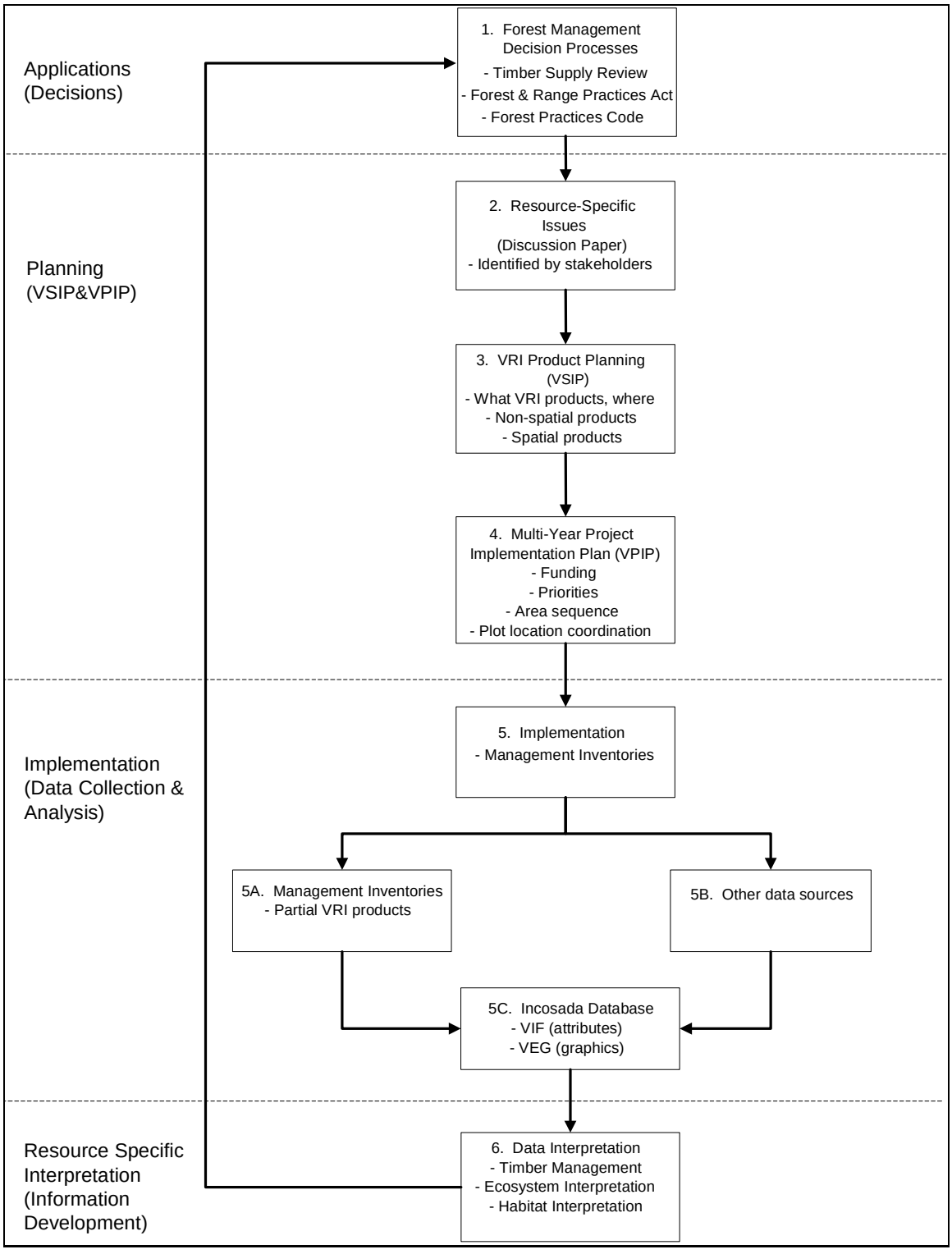

Figure 1. VRI planning process.

1.4 VRI Methodology

1.4.1 Phase I – Photo-Interpretation

Prior to commencing the VRI Phase I, a *VPIP for Photo Interpretation* must be completed and approved by the MoFR. This plan details photo acquisition requirements, the VRI Phase I process, standards for adherence, and a photo interpretation plan to implement the program.

Phase I is the photo interpretation phase of a VRI and entails polygon delineation and attribute estimation by certified photo interpreters using aerial photographs or digital images. The delineation identifies the location of the forest resources and the attribute estimation component provides estimates of numerous attributes including land cover type, crown closure, tree species, height, age, stand structure, basal area, density, slope position, moisture and nutrient regime, snags, shrubs, herbs, and bryoids. Estimation of attributes from field reference points is based upon field procedures using a combination of air and ground calibration points.

1.4.2 Phase II – Ground Sampling

Prior to commencing Phase II, a *VPIP for Ground Sampling* and NVAF destructive sampling plan must be completed and approved by the MoFR. This plan details the Phase II sample selection process and standards for adherence.

Specifically the Phase II VPIP plan will:

- Detail the Phase II project and sampling objectives;
- Identify target and identify sample populations, sample selection, and sample size details;
- Quantify any additional sample data that will need to be collected to address information gaps;
- Include discussion of the field program;
- Discuss the proposed data compilation, analysis, and statistical adjustment; and,
- Include the proposed implementation schedule.

The samples (samples are “plot clusters” and consist of a main plot and up to four associated auxiliary plots) selected for the Phase II ground sampling are based on the delineated polygons and attributes estimated during Phase I. Samples are selected randomly using a two-step process. First, polygons are selected proportional to area. Second, a random point is selected within the polygon. Comparison between the sample and the population are provided for key inventory attributes.

1.4.3 Net Volume Adjustment Factor

The MoFR VRI standards require all new VRI’s to complete an NVAF sampling program. This program involves detailed stem analysis of sample trees that have been randomly selected from the Phase II auxiliary plots. The NVAF is used to correct the VRI estimates of net close tree utilization for all species.

1.4.4 Statistical Adjustment

The final VRI phase is the statistical adjustment of the Phase I using the results of Phase II sampling data. NVAF information is used to adjust the Phase II sample estimates for hidden decay and taper equation bias and the Phase II plot estimates are used to adjust the Phase I photo

interpretation attribute estimates. The final product is a statistically valid new inventory, supported by re-adjustment of photo-estimated attributes based on ground samples.

1.4.5 Change Monitoring Inventory

A Change Monitoring Inventory (CMI) program takes measurements at timed intervals with the intent of monitoring change over time of key forest inventory attributes. These change estimates can then be compared to predictions from growth and yield models. One of the objectives of the CMI program is to act as an early warning system if assumptions used in growth and yield models are inaccurate. The CMI will only indicate that there is a problem with the model(s); it will not give information about the source of the problem. Special studies can be undertaken to investigate the source of the problem identified by the CMI program.

1.5 Funding

Funding for VRI activities is provided by the Forest Investment Account (FIA) Land Base Investment Program. All activities, timelines, and deliverables identified in this plan are subject to the provision of adequate government funding.

2.0 BUSINESS CONSIDERATIONS

2.1 Land Base

The Nass TSA is situated in northwestern British Columbia in the Northern Interior Forest Region (Figure 2) and covers approximately 1.6 million hectares (Table 1). The timber harvesting land base (THLB) in Timber Supply Review (TSR) 2 was 189,174 ha (12% of the TSA).[8]

The topography of the western part of the Nass TSA is mountainous with coastal plains and rugged ice-capped mountains. Almost all of the forest is either non-merchantable or is situated on environmentally sensitive locations, and is therefore currently unavailable for harvesting. The eastern portion is characterized by wide and flat plateaus bordered by the Skeena and Coast Mountain ranges.

The forests of the Nass TSA are reasonably homogeneous. Within the land base currently considered available for timber harvesting, western hemlock (Hw) leading stands cover about 70% of the area and sub-alpine fir-leading stands (Bl) cover about 20%. Lodgepole pine (Pl), sitka spruce (Ss), and western red cedar (Cw) also occur in this TSA, as do lesser amounts of deciduous forests and scattered wetlands.

Approximately 39% of the Nass TSA land base is considered productive forest land managed by the Crown (approximately 639,000ha). Currently about 30% of the productive Crown forest land is considered available for harvesting (12% of the TSA land base).

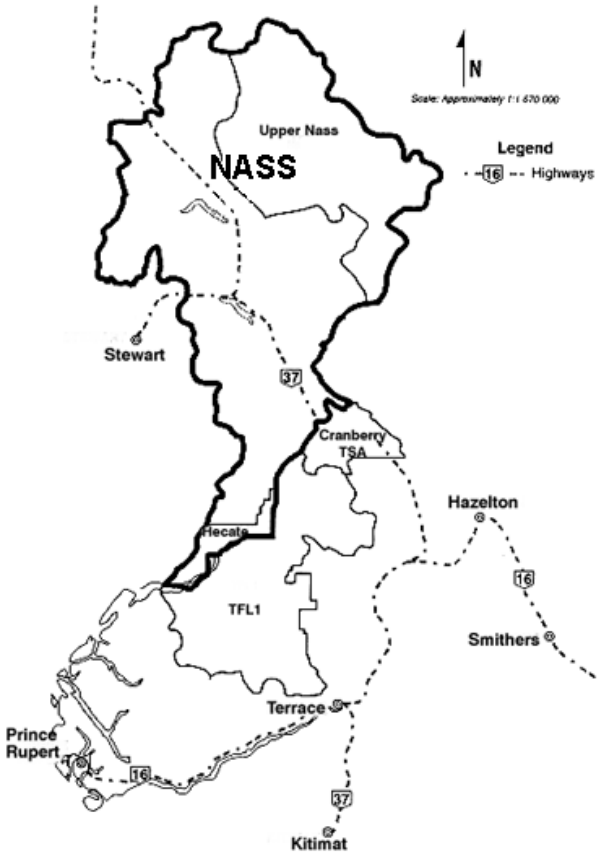

Figure 2. Overview map of the Nass TSA.[7]

Table 1. TSR 2 THLB net-down process.

Land Class	Area (ha)	% of TSA
Total TSA	1,620,271	
Non Crown Ownership	4,457	0%
Nisga'a Land	28,754	2%
Crown Ownership	1,587,060	98%
Non-Forested	960,450	59%
Forested	639,368	39%
Non-THLB	450,195	28%
THLB	*189,174*	*12%*

[7] This map is from the MOFR website.

[8] BC Ministry of Forests. 2001. Nass Timber Supply Area Analysis Report. Unpublished Report, June 2001. p. 3.

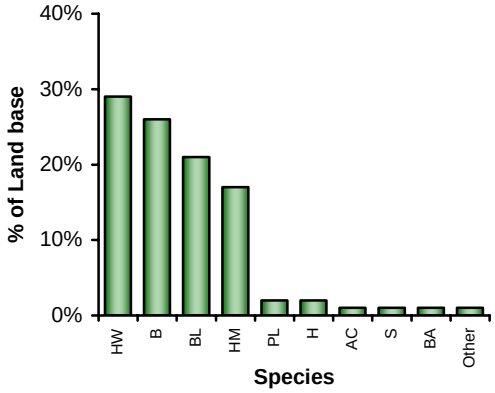

Figure 3. Species distribution in the vegetated treed portion of the Nass TSA.[9]

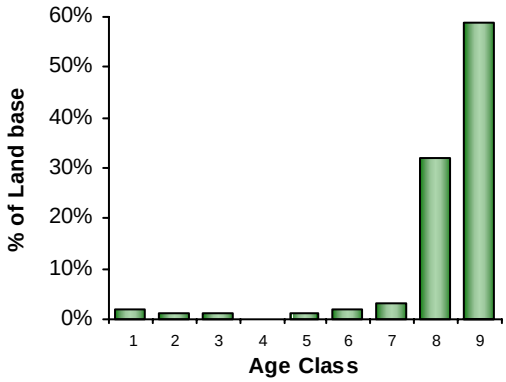

Figure 4. Age class distribution in the vegetated treed portion of the Nass TSA.[7]

2.2 First Nations

The Tahltan, Gitxsan, Gitanyow, and Nisga'a First Nation's groups have been identified as having aboriginal interest in the Nass TSA. The first three of these First Nations assert traditional territories within the Nass TSA. The rights and interests of the Nisga'a are set out in the Nisga'a Final Agreement (NFA) signed by the Nisga'a, and the Governments of Canada, and British Columbia.[10]

First Nations were consulted in preparation of this strategic inventory plan, and a letter from the District Manager has stated that all information sharing obligations with First Nations as per the FIA protocol have been satisfied.[11]

2.3 Current Forest Cover Inventory

Following a thorough review of the Nass inventory, it became clear that the inventory issues in this Management Unit are unique to BC. First, **the licensees lack faith in the current version of the forest inventory**[12] **and as such, have not used this inventory operationally for many years.** Second, because of unusually high staff turnover in both industry and government in this part of BC, it was not possible to find personnel with experience with this inventory who could offer informed opinion on the specific technical features of the inventory. Despite this, there are several features of the inventory that we do know, specifically:

- The majority of the inventory covering the Nass TSA is over 17 years old, and approximately one-third of the inventory (across the northern portion of the TSA) is more than 30 years old.

[9] Data used was obtained from the LRDW via Meg Hoole from the MoFR.

[10] Nass Timber Supply Area – Rationale for Annual Allowable Cut (AAC) Determination (August 2001)

[11] Kim Haworth – e-mail communication regarding first nations interests in Nass TSA.

[12] The licensees lack faith in both the accuracy of the polygon delineation and the associated attributes (i.e., height, age in particular).

- The inventory spans several periods, ranging from 1975 to 1989, with a few maps indicating inventory dates from 1990 to 1994 (along the north edge of the North Coast TSA).
- The inventory has been completed to at least two forest cover inventory standards, with several map sheets in the Taylor and Kwinageese landscape units having been completed to VRI Phase I standards in 2002.13

For that portion of the inventory that is more than 30 years old, we can likely assume the following:

- The polygons derived during this era are likely larger than observed in today's standards and not as accurate as users require.
- The process of defining attributes 30 years ago is very different than it is today, as is illustrated by the following example. In the earlier vintage, a person doing the inventory may have identified a label as Bl (Sw) 83M4 and was entered into a database for that polygon. Later, MoFR applied mid point values to all of those interpreted 'classes' so the data got turned into Bl90 Sw10 200 years 23.5 meters Medium site and 40% crown closure. On the surface, these might be seen as "accurate" descriptors, but are derived from an inaccurate process and then carried forward.
- The mapping was likely done with a Kale plotter, so the positional accuracy of the polygon boundary lines is likely off, probably by 30 metres or more.
- Polygon estimates of species mix, height and age are 30 years out of date. While many of the forests are old, the forests have changed in 30 years.

Despite the aforementioned observations, the 1997 audit of the Nass TSA forest inventory showed that there was no statistical difference between the inventory and ground volumes for the both the forested and operable land bases. However, these results are not consistent with the observations of stakeholders who believe that the current inventory understates polygon volumes.

[13] Map sheets included in this update include: 104a048, 104a049, 104a057, 104a058, 104a059, 104a027, 104a037, 104a038, 104a039, and 104a047.

2.4 Forest Management Considerations

The following forest management issues have been identified and discussed by the stakeholders:

Issue:	PHASE I IMPACT:	PHASE II IMPACT:	COMMENT
1. Western hemlock and balsam volume estimation	Low	High	Approximately 90% of the stands in the Nass TSA are covered by hemlock or balsam leading stands. The Chief Forester, District staff, and licencees identified the need to produce better merchantability estimates (i.e. hemlock taper and decay, waste, and breakage) in these stands. Studies in the Kalum TSA indicate taper is overestimating volume, loss factors were understating decay, and conk and blind conk affected trees were yielding more volume than estimates predict. A well-designed NVAF program would address these issues.
2. Site productivity	Med	Med	The AAC determination suggested that the inventory might under-estimate site productivity by as much as 57%. The ongoing SIBEC program should address this issue for managed stands.
3. Unsalvageable losses due to balsam bark beetle	N/A	N/A	This was identified as a non-issue.
4. Problem forest types	Low	Low	The main issue was NSR areas (~3,200ha). However, much of the NSR area has been reclassified as "stocked" through survey assessment.

Issue:	PHASE I IMPACT:	PHASE II IMPACT:	COMMENT
5. Existing forest cover attributes	High	High	The existing forest cover was completed to at least two inventory standards (the older 1975 portion is mid-point class based). More accurate Phase I attributes will provide refined delineation and stand attribute information (including species composition, age and height) to better define marginal value and volume types.
6. Operable land base	Low	Low	The licencees prefer concentrating ground sampling in the operable portion of land base, and confirm that the operable land base definition is stable. This area is small compared to the total TSA. The MoFR stated a concern that this approach may not provide an adequate level of information to support biodiversity information needs. The MoFR suggested a ratio of 80:20 or 90:10 of operable vs. non-operable ground samples. The final landbase selected for ground sampling will be determined in the Phase II VPIP.
7. Operational information	Low	Moderate	The licencees are interested in information on sawlog volume and other operational attributes. They prefer to use coastal grades to replace or compliment the standard VRI grades used in the ground sampling. The MoFR has advocated integrating coastal scaling data collection with NVAF data collection. Variances are available for the collection of non-standard data and can be considered at the project implementation plan stage.

8. Monitoring second growth stand performance	N/A	N/A	Improved information for younger stands was recognized as high priority to support the mid- to long-term timber supply for the TSA. Implementing a Change Monitoring Inventory (CMI) program might be better suited for monitoring young stands, growth and yield, and auditing yield tables. Most information for regen in Phase I (non-free growing) will come from silviculture information and RESULTS. Monitoring for regen forest health is ongoing.

2.5 Summary of Inventory Issues

The following list summarizes the inventory requirements identified by the Nass stakeholders. The Nass stakeholders (licensees and government) no longer use the current forest inventory for any forestry planning activities. Thus, there is a need for both industry and government to have an inventory that supports traditional forestry activities. These include, but are not limited to, the need for the inventory to:

- Provide better species composition and age/height estimation attributes for all forested polygons.
- Provide statistically valid polygon-level estimates of height, age, and volume.
- Have more accurate polygon delineation (to VRI specifications).
- Include disturbance updates.
- Be consistent with adjacent Management Units that are in the process of being updated to VRI standards.
- Quantify non-recoverable (gross) losses from fire, insects, disease, and wind-throw.
- Support other inventories that use the forest cover as the basis for their inventory.[14]
- Provide information on the provincial park component so that it contributes to seral stage balancing, old growth management, and habitat and rare ecosystem representation.
- Provide more accurate loss factors and taper equations.
- Satisfy forest certification requirements.
- Be in a consistent and accessible format.
- Have more accurate information on polygons aged 30 to 140 years.

Despite the 1997 inventory audit results, the Nass TSA stakeholders believe that the forest inventory is outdated and does not meet their current and future needs. Specifically, the stakeholders require a new VRI to provide the following:

[14] The Nass TSA Predictive Ecosystem Map (PEM) did not meet minimum standards for Accuracy Assessment. It is believed that poor forest cover inventory attributes were one of the reasons why the PEM did not meet minimum standards.

1. Incorporate more reliable inventory estimates into the Nass TSA TSR process.
2. Provide improved species composition, height and age estimates, and improved stand structure identification (especially conifer understory information) for forest planning purposes.
3. Include the Swan Lake - Kispiox River Provincial Park and other parks in the inventory area that contribute to seral stage balancing and old growth management.
4. Information to support management of non-timber values such as wildlife habitat and rare ecosystem representation.
5. Correct historical polygon mapping irregularities and associated outdated attribute estimation methods by updating new forest cover onto new TRIM II Base.

3.0 STRATEGIC INVENTORY PLAN

3.1 Overview

This section outlines the strategic inventory plan to implement VRI products to address the business issues discussed in Section 2.4. The existing 'potential' VRI products include 2001 and 2003 scanned 1:30,000 black & white aerial photographs (DiAP *viewer* sets) over the majority of the Nass TSA that were flown for use in this project. These, or replacement photos will be used to support a new spatial vegetation inventory (VRI Phase I) for the entire Nass TSA. The next step is to complete a timber emphasis (VRI Phase II) and NVAF program. The final step is the statistical adjustment of the Phase I inventory using the results of the timber emphasis ground sampling program. Most of the identified business needs will be addressed through completion of the VRI photo interpretation and field calibration data collection, ground sampling, and statistical adjustment.

3.2 Phase I – Photo-Interpretation

3.2.1 Pre-Inventory Assessment

In order to provide greater certainty around the technical limitations of the current inventory, a Pre-Inventory Assessment should be completed prior to the start of the Phase I program to provide additional justification for funding of a Phase I program.

3.2.2 Objective

The objective is to use photo-interpretation and field calibration to improve polygon-level inventory information on the Nass TSA. The VRI Phase I product is a spatial database consisting of unadjusted photo-interpreted estimates based on field calibration data.

3.2.3 Target Area

The entire Nass TSA (not including the Nisga'a lands) is scheduled to be updated to VRI standards through new photo-interpretation. This includes woodlots and Swan Lake Park.

3.2.4 Target Attributes

All attributes listed on the VRI photo interpretation attribute form will be targeted. These attributes will be interpreted to the most current VRI photo-interpretation standards.[15]

3.2.5 Aerial Photo Acquisition Options

The existing aerial photographs photos (1:30,000 scale, black & white flown in 2001and 2003) were reviewed to determine their suitability for use in this project.[16] This review found that the 2001 photos (located in the Lower Nass TSA) were not suitable for use in the VRI Phase I because of the poor contrast and resolution that would make accurate delineation and attribute estimation impossible. Conversely, the 2003 aerial photos covering the Upper Nass were shown

[15] A complete listing of VRI attributes is found in the *Vegetation Resources Inventory Photo Interpretation Procedures* manual at http://ilmbwww.gov.bc.ca/risc/pubs/teveg/vri-photointerp2k2/photo_interp2k2.pdf

[16] A random sample of images were reviewed in softcopy by Dick Nakatsu of the MoFR Northern Interior Forest Region and Mike Sandvoss of Timberline Natural Resource Group Ltd.

to be marginally acceptable for photo-interpretation provided that additional focus is given to field calibration in these areas.

Following review of several options, the stakeholder group chose to review DiAP viewer models of all 2003 photo coverage in 2006/2007 to determine images that are not acceptable and subsequently fly these along with the areas covered in 2001. Depending upon the chosen scale and emulsion (black & white or colour), the assumed cost for 130 map sheets for 1:15,000 colour is $421,850, 1:20,000 colour is $352,300, and 1:20,000 black & white extended red is $304,850.

The advantages, disadvantages, and costs associated with the different options are provided in Appendix II.

3.2.6 Methods

The Phase I inventory will be completed to MoFR standards using digital photogrammetric (softcopy) technology. 1:15,000 to 1:20,000 scale colour aerial photographs are the preferred scale and emulsion used for VRI with softcopy technology. The available viewer sets for the TSA are 1:30,000 (black & white) and were found to be either not suitable or marginally suitable for inventory interpretation purposes.

The Nass TSA aerial photographs were acquired in 2001 and 2003 with the intent of supporting multiple uses, including creating high-resolution orthophotos as part of a TRIM II project. A small portion of the TSA is not covered by current photography. These gaps exist around the edge of the TSA mostly in the non-vegetated alpine. The current aerial photographs coverage is summarized as follows:

Photo Year	**Approximate Location**	**Area (ha)**
2001	South of Bowser Lake	970,000
2003	North of Bowser Lake	650,000
Total		*1,620,000*

As per current MoFR standards, air and ground field calibration will be established by photo-interpreters to gain local knowledge and improve VRI attribute estimation. Field calibration will predominantly target stands not calibrated in the previous inventory, in particular, those stands and species groups where the age and height information requires more focus.

3.2.7 Costs

The VRI Phase I costs will be finalized once the exact parameters of the inventory are determined. The approximate cost should be between $0.90 and $1.10/ha based on other recent TSA inventory costs with standard field visitation. The cost per hectare estimate increases if field visitation is increased (i.e., for a more 'operational' Phase I inventory). Note that this cost does not include the acquisition of additional aerial photographs. The VPIP will outline in more detail the implementation of the Phase I.

Third party quality assurance is required. The approximate costs of quality control and assurance for the delineation, field calibration, and attribute estimation are presented in Table 2.

3.3 Phase II – Ground Sampling

3.3.1 Objective

The primary objective of the ground-sampling component of the VRI program is to install enough Timber Emphasis Plots (TEP) to estimate the average net merchantable volume in the target population with a sampling error of ±10% at a 95% confidence level.

3.3.2 Target Population

The target population will be the operable portion of the Vegetated Treed (VT) area within the TSA, 30 years or older. The choice of sampling outside the operable land base will depend upon available funding.

3.3.3 Sample Size

The coefficient of variation (CV) for the ratio of means of the inventory audit versus the mature volume of the inventory was 32%.[17] If this is increased by 10% to 42%, this means that 75 samples are required to achieve the target sampling error of ±10%. Conversely, a CV of 32% the sampling error would be ±8%.

3.3.4 Sampling Approach

Phase II certified timber samplers will install all VRI TEPs to VRI ground sampling standards.[18] Sampling will follow a two-stage approach. The first stage will be focused at meeting the primary objective of installing a minimum number of TEPs (approximately 50) to support the information needs of the NVAF program. The second stage will be to install enough TEPs to achieve a target sampling error of ±10% at a 95% confidence level (likely 25 plots). This approach will be refined and updated in the VRI Phase II project implementation plan.

3.3.5 Sample Selection

Sample locations will be selected using the standard MoFR method. First, polygons will be selected using the probability proportional to size with replacement (PPSWR) method. Second, a random point will be selected within the selected polygon using the provincial 100-m grid. If no 100-m grid point falls within the selected polygon, the grid will be halved until at least one point falls within the polygon.

3.4 Net Volume Adjustment Factor

3.4.1 Objective

The objective of the NVAF component is to estimate NVAF ratios with a sampling error of ±7.5% at a 95% confidence level.

NVAF sampling involves detailed stem analysis of sample trees, calculation of actual net volume, and calculation of the ratio between actual net volume and estimated net volume. This ratio is used to statistically adjust the estimate of net merchantable volume of VRI ground samples.

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[17] The CV of the ratio of means was calculated using the 1997 Nass inventory audit results for the analysis of mature volumes.

[18] http://ilmbwww.gov.bc.ca/risc/pubs/teveg/vri_gs_2k4/vri_gs_2k4.pdf

3.4.2 Sample Size

The MoFR requires a minimum sample size of 100 NVAF trees of which 75 are live and 25 dead. The final sample size and distribution by species will be determined during development of the Phase II VPIP. The relative species distribution (in terms of net merchantable volume) will be estimated and the actual sample size for each species group determined based on the species distribution.

The stakeholders specifically noted that tree taper is an area of uncertainty and believe that current taper equations do not adequately model trees in the Nass TSA. The NVAF will be able to provide some certainty to the size of the errors due to the taper and loss, which can guide future sampling efforts that would be required to adjust the taper and net factors.

3.4.3 Sample Selection

The number of VRI Phase II plots that will be enhanced for NVAF sampling will be determined following discussion with MoFR and will be updated in the VRI Phase II VPIP. Following completion of the first stage of the Phase II ground sampling program, a tree matrix will be built with all trees from the auxiliary plots of the NVAF-enhanced samples. The sample in each matrix cell will be selected systematically with a random start after the tree list in the cell is sorted by species and diameter at breast height (DBH).

3.5 Change Monitoring Inventory

CMI is considered an important component to track the modeling assumptions used for second-growth stands. The stakeholders intend to implement a CMI program in stands less than 30 years of age as information on the mid to long-term timber supply was identified as a business priority.

3.6 Estimated Costs

The costs provided below include the additional costs for re-flying the 2001 photo areas and portions of the 2003 photo area so that suitable photos are used during the Phase I program. The total project cost is approximately $2,500,000, of which approximately $400,000 needs to be spent on new photos and approximately $2,100,00 is required to complete the full suite of VRI activities (Table 2).

Table 2. Estimated costs for VRI activities in the Nass TSA.

VRI Activity	Units	Unit Cost ($/Unit)	Total Cost ($)
PHOTO ACQUISITION (100% COVERAGE)	130 @ 1:15,000 Colour	$3,245/Sheet	$421,850
	130 @ 1:20,000 Colour	$2,710/Sheet	$352,300
	130 @ 1:20,000 B&W	$2,345/Sheet	$304,850
PHASE I			
Phase I VPIP	1	$7,500	$7,500
Phase I VRI		$1.00/ha	$1,600,000
Quality Assurance	1	$0.03/ha	$48,000
Sub-Total			*$1,655,500*
PHASE II			
Phase II VPIP[a]	1	$15,000	$15,000
Timber Emphasis Plots	75	$1,700/plot	$127,500
Helicopter	60	$1, 000/hr	$60,000
Quality Assurance	8	$1,700/plot	$13,600
Sub-Total			*$216,100*
STATISTICAL ADJUSTMENT			
Data compilation	1	$1,000	$1,000
Adjustment, NVAF Analysis & Report	1	$20,000	$20,000
Sub-Total			*$21,000*
NVAF			
VPIP Update / Tree Selection	1	$2,000	$2,000
Destructive Sampling	100	$750/tree	$75,000
Sub-Total			*$77,000*
CMI			
CMI VPIP	1	$10,000	$10,000
Plot Establishment	50	$1,700/plot	$85,000
Quality Assurance	8	$1,700/plot	$13,600
Installation Report	1	$5,000	$5,000
Sub-Total			*$113,600*
Photo-Acquisition Total (Price Range)			***$304,000 - $422,000***
VRI Activities Total			***$2,083,200***
Approximate Total Cost			***$2,500,000***

4.0 SIGN-OFF SHEET

The Nass TSA VRI Strategic Inventory Plan, dated March 2007, meets current VRI standards and stakeholders business needs and considerations. It is the intention of the lead proponent to implement this plan as described, although it is understood that this is an agreement-in-principle and does not commit the signatories to completing the inventory activities outlined in the plan.

_____ _____

Jon Vivian, R.P.F. Manager, Date

Vegetation Resources Inventory Section,
Forest Analysis and Inventory Branch,
Ministry of Forests and Range

_____ _____

West Fraser Mills. (lead proponent) Date

APPENDIX I – GLOSSARY OF TERMS

Ground Sampling

VRI ground sampling (Phase I) is the field measurement of timber, ecology, range, and/or coarse woody debris values at one or more locations within each sample polygon. To accommodate the wide variety of resources, various types and sizes of sampling units (e.g., fixed and variable plots, transects) are used to make the measurements.

Landcover Classification

The BC Landcover Classification Scheme (BCLCS) was designed specifically to meet the requirements of the VRI, in addition to providing general information useful for "global vegetation accounting" and "integrated resource management". The BCLCS is hierarchical and reflects the current state of the landcover (e.g., presence or absence of vegetation, type and density of vegetation) and such fixed characteristics as landscape position (i.e., wetland, upland, alpine). There are two main classes of polygons: Vegetated and Non-Vegetated.

Net Volume Adjustment Factor (NVAF) Sampling

NVAF sampling provides factors to adjust net tree volume estimated from net factoring and taper equations. The adjustment accounts for hidden decay and possible taper equation bias. NVAF sampling involves detailed stem analysis of sample trees, calculation of actual net volume, and calculation of the ratio between actual net volume and estimated net volume (where estimate net volume is obtained from net factoring and taper equations).

Photo-Interpretation (Phase I)

Photo-interpretation (Phase I) involves the subjective delineation of polygons and the photo estimation of attributes for all polygons in an inventory unit. Medium scale aerial photographs (1:15,000) are most often used in the photo-interpreted estimates inventory.

Post-Stratification

Post-stratification involves the division of an inventory unit into mutually exclusive sub-populations (strata) *after* ground sampling has been completed. Samples that fall in each post-stratum are analyzed separately and the results are applied to the corresponding population post-strata.

Pre-Stratification

Pre-stratification involves the division of an inventory unit into mutually exclusive sub-populations (strata) *before* ground sampling to provide estimates for specific areas, or to increase the confidence in the overall estimates by considering the special characteristics of each stratum.

Sample Size

The sample size for an inventory is the minimum number of ground samples to be established in an inventory unit to meet specified target precision or cost. Calculation of a theoretical target sample size requires an estimate of the CV of the key attributes of interest under the proposed sampling procedures and a statement of the precision desired in these attributes.

The formal process for determining sample size for an inventory unit is to anticipate the results (e.g., target sampling error for timber volume) and then determine the approximate sample size corresponding to this desired result. This process would, for example, involve the following steps:

1. Set the target accuracy for the overall inventory unit accuracy to *E* for timber volume (i.e., the sampling error, or half the confidence interval associated with a given probability, e.g., ±15% at the 95% probability level). The number of samples should be adequate to meet the target precision.
2. Estimate the population coefficient of variation (CV_{sample}) of the attribute of interest based on a small sample. This CV_{sample} is defined as a relative measure of the average difference between a polygon ground measurement (assumed the true value) and its corresponding estimate from the inventory.
3. The following formula would then be used to estimate sample size:

$$n = [\frac{t * CV_{sample}}{E}]^2$$

where *t* is the "*t*-value" associated with a given probability and degrees of freedom, and CV_{sample} is a sample-based estimate of the population CV.

The sample size calculations suggested here are general guidelines, not exact requirements. The sample size used in practice is usually a trade-off between the calculated sample size and the expected cost, timing, credibility, flexibility, and comparability of the inventory. The size of the population is usually large enough that it does not affect sample size. The calculated sample size may be increased arbitrarily to allow for post-stratification, increased credibility, more flexibility, and a better starting point for growth projections.

Statistical Adjustment

Statistical adjustment (or analysis) is the process of adjusting the values of the photo-interpreted estimates variables using the ground sampling observations. For each sampled polygon, the ground observations are compared to the photo-estimated values to develop an adjustment factor. This factor is then applied to all polygons in the photo-interpreted estimates database to produce the final adjusted database.

Sub-unit

The term sub-unit describes the inventory unit within a management unit. A sub-unit may be defined by a specific geographic area (e.g., operable land base) or stand type (e.g., problem forest types) within the management unit.

Target Population

The target population is the unit from which the samples are chosen. For management inventories, the inventory unit is a TSA, TFL or other geographic area or specific attribute set, depending upon the sampling objectives.

Target sampling error

Target sampling error expresses the desired accuracy of the attribute of interest (e.g., timber volume). It is usually expressed as a percentage value at a given probability level (e.g., ±10 at the 95% probability level). This means that 95% of the time we are confident that the volume

estimates are within 10% of the actual volume. Target sampling error is used to calculate the minimum sample size for subsequent ground sampling; see ***Sample Size***.

Vegetation Resources Inventory (VRI)

The VRI is an improved vegetation inventory process for assessing the quantity and quality of BC's vegetation resources. The VRI process is designed to include a flexible set of sampling procedures for collecting vegetation resource information. The VRI is essentially a toolbox of procedures, which include:

- BC Landcover classification scheme (BCLCS).
- *Photo-interpreted estimates (Phase I)*: the delineation of polygons from aerial photography and the estimation of resource attributes.
- *Ground sampling (Phase II)*: the establishment of plot clusters in selected polygons to measure timber, ecological, and/or range attributes. The data are used for the adjustment of the photo-interpreted estimates for all polygons in an inventory unit or management unit.
- *NVAF Sampling*: Stem analysis sampling of individual trees for net volume adjustment.
- *Change Monitoring Inventory (CMI).*

The VRI can be deployed over the entire province (provincial VRI) measuring timber and non-timber resources, or over a large management unit (management VRI) measuring selected resources in specific portions of the land base. The VRI sampling process produces spatial and non-spatial databases that can be used in multiple resource management applications including timber, ecosystem, and wildlife habitat management.

APPENDIX II – PHOTO PURCHASE OPTIONS REVIEW

The existing aerial photographs (1:30,000 scale, black & white flown in 2001and 2003) were reviewed to determine their suitability for use in this project.[19] This review found that the 2001 photos (located in the Lower Nass TSA) were not suitable for use in the VRI Phase I because of the poor contrast and resolution that would make accurate delineation and attribute estimation impossible. Conversely, the 2003 aerial photos covering the Upper Nass were shown to be marginally acceptable for photo-interpretation provided that additional focus is given to ground calibration in these areas.

Following review, three options were presented to the stakeholders to ensure that adequate photos are used in this project:

1. Fly all of the Nass TSA (approximately 159 map sheets)
    - Advantages:
        - Consistency of aerial photo coverage with a scale and emulsion more suitable for achieving the inventory results.
    - Disadvantages:
        - Cost and timing. The Nass TSA is large and therefore costly to acquire mid scale aerial photographs. The Nass TSA is consistently affected by coastal weather patterns and may require more than one year to fly new photos.
    - Costs:
        - 159 map sheets 1:15,000 colour: $515,955
        - 159 map sheets 1:20,000 colour: $430,890
        - 159 map sheets 1:20,000 black & white extended red: $372,855
2. Re-acquire aerial photographs at 1:15,000 or 1:20,000 colour (approximately 130 map sheets) for the Nass TSA except map sheets covered by the 2003 1:30,000 scale aerial photographs.
    - Advantages:
        - Cost and time savings. The area requiring aerial photograph acquisition (Lower Nass) is marginally reduced and predominantly where most of the timber harvest land base exists. Reducing the size of the area to re-fly, increases the chances of completing the program in one flight.
    - Disadvantages:
        - The Nass TSA will be covered by two different scales and emulsions with a time gap of four years between flights (assuming complete re-acquisition in 2007). The marginal suitability of the 2003 1:30,000 scale black & white aerial photographs can be covered off by a slight increase in field calibration intensity

[19] A random sample of images were reviewed in softcopy by Dick Nakatsu of the MoFR Northern Interior Forest Region and Mike Sandvoss of Timberline Forest Inventory Consultants Ltd.

(slightly increased field calibration cost).

- Costs:
  - 130 map sheets 1:15,000 colour: $421,850
  - 130 map sheets 1:20,000 colour: $352,300
  - 130 map sheets 1:20,000 black & white ext red: $304,850

3. Review DIAP viewer models of all 2003 photocoverage in 2006/2007 to determine images that are unacceptable and refly these along with the areas covered in 2001.
   - Advantages:
     - Cost and time savings. The area requiring aerial photograph acquisition (Lower Nass) is reduced and predominantly where most of the timber harvest land base (THLB) exists. Reducing the size of the area to re-fly, increases the chances of completing it all in one flight. This facilitates the use of some of the 2003 photos, and allows photo interpretation of areas with acceptable coverage in the 2006/2007 fiscal year.
   - Disadvantages:
     - The Nass TSA will be covered by two different scales and emulsions with a time gap of four years between them flights (assuming complete re-acquisition in 2007). The marginal suitability of the 2003 1:30,000 scale black & white aerial photographs can be addressed by a slight increase in field calibration intensity (slightly increased field calibration cost).
   - Costs:
     - 130 map sheets 1:15,000 colour: $421,850
     - 130 map sheets 1:20,000 colour: $352,300
     - 130 map sheets 1:20,000 black & white ext red: $304,850

Upon review of the different approaches, the stakeholders chose Option 3.