# Quesnel
# Timber Supply Area

## Vegetation Resources Inventory

### Strategic Inventory Plan

**PREPARED BY:**

**QUESNEL TSA STAKEHOLDERS COMMITTEE**

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## EXECUTIVE SUMMARY

This Vegetation Resources Inventory (VRI) Strategic Inventory Plan (VSIP) outlines the VRI activities and products that address forest management and inventory issues in the Quesnel Timber Supply Area (TSA). The stakeholders for this project include West Fraser Mills Ltd. (lead), Tolko Industries Ltd., Canfor Ltd, the Ministry of Forests, the Ministry of Agriculture and Lands – LIBC (formerly MSRM), and the BC Parks Branch and Ecosystems Section of the Ministry of Environment (formerly MWLAP).

The following VRI activities and products are planned:

1. Acquire 1:20,000 scale colour aerial photographs in 2005 of the entire TSA, including the two TFL's (5 and 52) and all parks and protected areas in support of Phase I of the VRI, proposed to commence in 2006.
2. Conduct a softcopy Phase I VRI photo-interpretation (starting in 2006), over the entire Quesnel TSA (including all parks and protected areas, but excluding the TFL's as these were VRI'd in 1999 and 2002). The Phase I VRI will support timber-emphasis inventories, vegetation mapping, habitat mapping, riparian mapping, mountain pine beetle attacked shelf life modelling, reforestation and stand tending, and other applications.
3. Conduct finer polygon delineation (pilot) to address stands (particularly lodgepole pine dominated) with conifer understories.
4. Update the TRIM II base mapping for the TSA (according to current specifications published by Base Mapping and Geomatic Services) concurrently with the Phase I VRI, including a roads and trails reclassification. This will be undertaken as separate projects for Quesnel TSA, TFL 5 and TFL 52, providing that FIA or other funding can be secured.
5. Conduct Phase II VRI timber emphasis ground sampling (permanent, non-standard, and innovative design) in the Vegetated Treed area of the TSA to provide statistically valid timber volumes and polygon-specific tree attributes for the subsequent timber supply reviews and to address scheduled monitoring.
6. Explore innovation or changes in standard VRI applications and other processes to address and monitor the MPB effects on the inventory as well as the effects of mountain pine beetle driven forest management practices.

The approximate (estimated) number of ground sample plots and costs for the proposed VRI activities are given in Table 4 of this report.

These VRI activities and products will support timber supply objectives and other resource specific interpretations. They may be implemented in smaller units (Supply Blocks, Management Zones, etc.) across the TSA. They may also be jointly implemented to address common management issues within the Southern Interior Forest Region.

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# 1.0 INTRODUCTION

## 1.1 Background

The Quesnel TSA is in the latter stages of a widespread and severe epidemic of mountain pine beetle that has caused massive mortality of lodgepole pine. The result of the epidemic has been an uplift in the allowable annual cut from 2.3 million $m^3$ per year to 5.28 million $m^3$, leading to extensive harvesting for control and salvage, disruption in long-term resource planning, and uncertainty about future consumptive and non-consumptive forest values.

The report "Timber Supply and the Mountain Pine Beetle" (MoF, 2003), estimated that pine-leading stands in the Quesnel TSA cover 590,000 ha, with a total mature pine volume of 105 million cubic metres. The loss of this volume, through salvage and non-recovery over time, is projected to lead to a substantially reduced AAC in the range of 1.365 million $m^3$ per year, which would have a dramatic effect on employment, community stability, and government revenue.

There is considerable uncertainty with respect to the severity of attack across the landscape and what volume may be left after the epidemic. In addition, there is little or no information about what species and numbers of regenerating trees may be present in the understory of damaged stands as these understories are often not reported (or not reported well) in the inventory.

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

The Quesnel TSA Stakeholders Group (see Appendix I) is comprised of participants operating within the Quesnel TSA, including West Fraser Mills Ltd. (lead), Tolko Industries Ltd., Canadian Forest Products (Canfor) Ltd., the Ministry of Forests, the Ministry of Agriculture and Lands - LIBC, and the BC Parks Branch and Ecosystems Section of the Ministry of Environment.

## 1.2 VRI Overview

The VRI is a two phased vegetation inventory process, approved by the 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, efficient, statistically defensible, and addresses issues raised by the Forest Resources Commission in its 1991 report, *The Future of Our Forests*, including:

1. Lack of statements of precision of the inventory.
2. Inadequate information on non-timber vegetation resources.
3. Lack of reliable estimates of growth rates and stand specific volumes.
4. Narrow focus on commercial timber volume and the timber harvesting land base.

The VRI consists of several components (see Appendix III for definitions):

1. Derived BC Land Cover Classification Scheme (BCLCS).
2. Photo Interpreted Estimates (Phase I).

3. Ground Sampling (Phase II) – timber emphasis, ecology, coarse woody debris.
4. Net Volume Adjustment Factor (NVAF) sampling.
5. Within Polygon Variation (WPV) sampling.
6. Statistical Adjustment.

One or more of these components can address specific forest management or inventory issues. For more information, VRI manuals are available through the internet at http://srmwww.gov.bc.ca/risc/pubs/teveg/index.htm.

### 1.3 VRI Planning

The VRI planning process requires that a VSIP and VRI Project Implementation Plan (VPIP) are developed for defined units (e.g. TSA, TFL). A VSIP outlines the VRI products that will address local forest management issues and needs, and provides the strategic direction for implementing the inventory activities such that these needs will be met. A VPIP details the operational activities identified in the VSIP (e.g. Phase I VRI photo interpretation project, Phase II VRI ground sampling) and identifies project areas, priorities, plot location, yearly inventory costs, and roles and responsibilities. Guidelines for preparing the VSIPs and VPIPs are available on the Internet at http://srmwww.gov.bc.ca/tib/fia/vri.htm.

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

1. Forest management decision processes (land integration planning, silviculture planning).
2. Identifying forest management issues.
3. VRI Strategic planning (preparation of a VSIP).
4. VRI operational planning (preparation of VPIPs).
5. Implementation, including development and maintenance of procedures and standards;
    a). Management inventories;
    b). Database management; and
    c). Data interpretation.

The steps for preparing a VSIP include:

1. Licencee stakeholders work with LIBC and MoF staff to develop issue statements related to VRI.
2. The Quesnel TSA Stakeholder Group meets 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). Table new issues and issues recorded to date;
    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; and
    d). Suggest the VRI tools to address currently fundable issues as well as those issues that may be funded in the future.

3. The Quesnel TSA Stakeholder Group meeting minutes are prepared and circulated to all participants for review and feedback.

4. The Quesnel TSA Stakeholder Group prepares a preliminary VSIP, which is reviewed and discussed through a conference call.
5. The Quesnel TSA Stakeholder Group prepares a final VSIP, which incorporates items agreed to in Step 5 and is signed off by committee members, MOF, LIBC, BMGS
6. The VPIP process begins.

The steps for preparing a VPIP 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.

## 1.4 Funding

The Quesnel TSA Stakeholder Group will develop criteria for setting VRI activity priorities and products identified during the planning process. Currently, funding for VRI activities are FIA eligible. Forests for Tomorrow (FFT) funds have been provided to acquire new aerial photography for the project. As there will be innovative aspects of this project that will be tailored to address resource management issues resulting from the MPB epidemic, it is expected that FFT funding will continue in 2006.

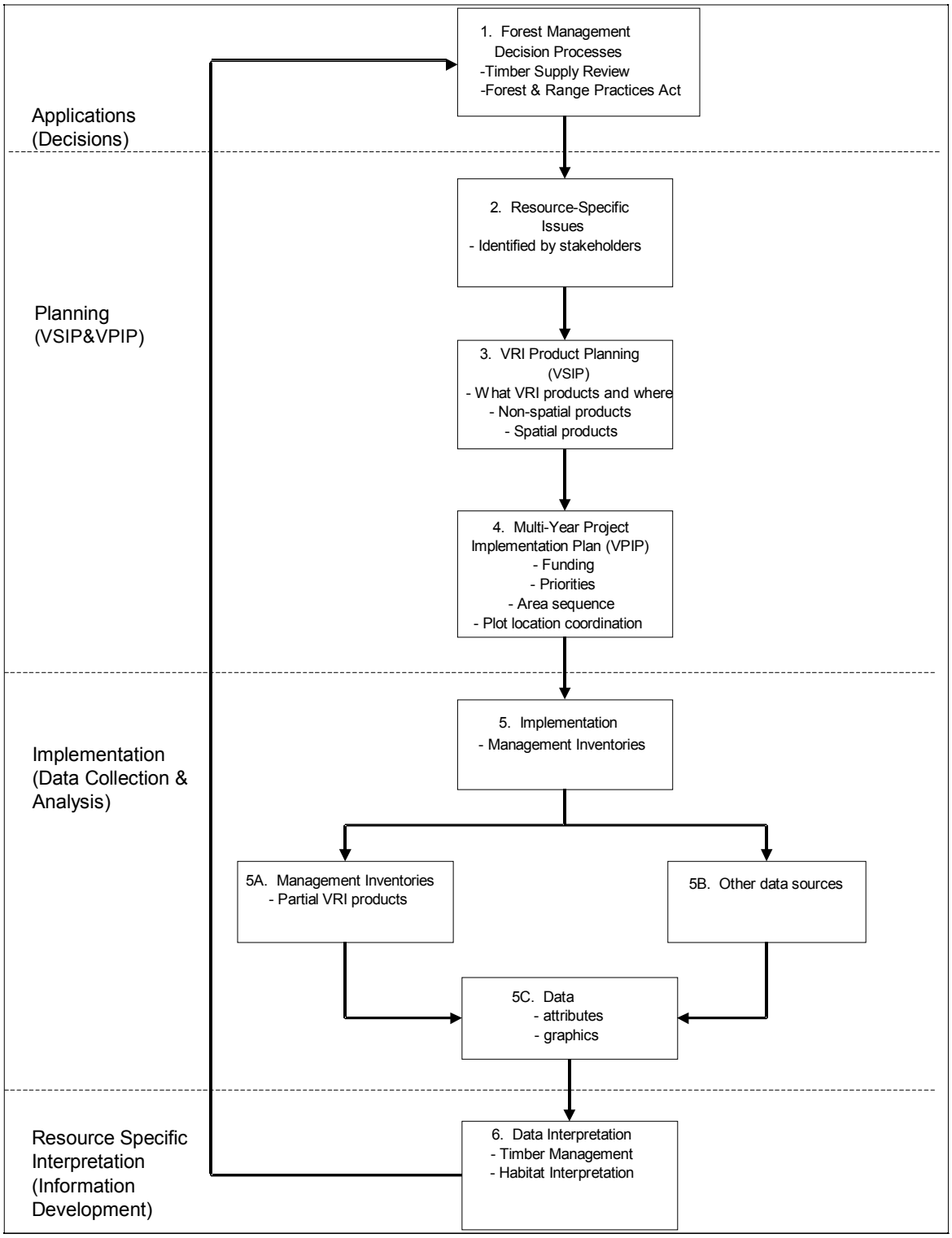


**Figure 1 The VRI Management Inventory Process**

# 2.0 BUSINESS CONSIDERATIONS

## 2.1 Land Base

The Quesnel Forest District covers approximately 2,077,253 ha., with the TSA covering 1,603,111 ha. (see Table 1 for a further breakdown of the land base). The main tree species in the forested land base are broken down by area as follows: lodgepole pine (74.3%), hybrid white spruce (13.8%), Douglas-fir (4.9%), trembling aspen (3.8%), sub-alpine fir (2.0%), with cedar, hemlock, birch, cottonwood, and larch (1.2%) forming minor components (see Table 2). In this report, the assumption is made that the forested land base corresponds to the Vegetated Treed (VT) land base according to the BC Land Cover Classification Scheme, or BCLCS.

**Table 1 Quesnel TSA Area Summary**

| Landbase Classification | Area (ha) | Percent (%) |
|---|---|---|
| **Total Forest District** | **2,077,253** | **100** |
| TFL 5 and 52 | 295,243 | 14.2 |
| **Total TSA** | **1,603,111** | **85.8** |
| Non Forest | 180,989 | 13.3 |
| Non-Crown | 75,932 | 3.0 |
| Woodlots/Schedule N | 20,456 | 6.1 |
| Parks | 23,957 | 0.3 |
| **Productive Landbase** | **1,025,810** | **63.1** |
| Non Commercial | 505 | 0.0 |
| Caribou | 71,063 | 3.1 |
| Lake Buffers | 2206 | 0.0 |
| Non-merchantable | 64,094 | 1.9 |
| ESA | 8,919 | 0.2 |
| Low Productivity | 16,667 | 0.6 |
| Riparian | 26,602 | 0.8 |
| Residual Non-Merch | 2,406 | 0.1 |
| Current Roads | 30,454 | 1.6 |
| WTP | 37,315 | 2.2 |
| Deciduous | 14,908 | 0.6 |
| OGMA | 94,967 | 4.6 |
| **Total Productive Reductions** | **290,889** | **15.9** |
| **Timber Harvesting Land Base** | **999,327** | **47.2** |

**Table 2 Quesnel TSA Tree Species Distribution by Area and Volume in the Productive Forest Land Base (approximation)**

| Tree Species | Area (ha) | Area (%) | Volume (m3) | Volume (%) |
|---|---|---|---|---|
| Lodgepole pine | 1,118,208 | 74.3 | 154475002.6 | 66.1 |
| Spruce (Sx) | 207,689 | 13.8 | 49059034.6 | 21.0 |
| Douglas-fir | 73,745 | 4.9 | 12302635.7 | 5.3 |
| Trembling aspen | 57,190 | 3.8 | 6396321.2 | 2.7 |
| Sub-alpine fir | 30,100 | 2.0 | 7978292.3 | 3.4 |
| Other (Cw, Hw, Ep, Act & L) | 18,060 | 1.2 | 3385882.9 | 1.5 |

## 2.2 Forest Management Considerations

Significant forest management issues in the Quesnel TSA were highlighted in the last timber supply review determination (TSR 2 Rationale for AAC determination update, October 1, 2004). These issues are summarized in Table 3.

Other emerging data needs were considered to be relevant to the Quesnel TSA and could be addressed with a completed VRI.

1. Mitigation of short-term losses through directed fertilization.
2. Link to PI shelf life modelling undertaken in other districts.
3. Improved harvest scheduling based on salvage schedule.
4. Planned 'abandonment' of timber that can't be harvested before it becomes un-useable
5. Identification of regeneration and stand tending opportunities and options.
6. Park inventories, because of park contributions to seral stage balances, habitat representation, and old growth management.
7. Growth and yield linkages. A predictive ecosystem mapping (PEM) project is nearing completion in the TSA; the planned next step is to undertake a site index adjustment project based on the PEM.
8. Market certification requirements.

**Table 3 Forest Management Issues for the Quesnel TSA Related to the Inventory**

| Issue | Remarks |
|---|---|
| | |
| 1 Site productivity: determine extent of species conversion upon regeneration. | Measurements from Phase II plots can be used to check existing site index estimates. However, these data will not address the issue of stand productivity, nor will they correct deficient site curves.<br>Establish a framework to track changes in species composition over time in MPB affected stands. |
| 2 Site productivity: review information from | The problem forest type 'inventory' is was |

| Issue | Remarks |
|---|---|
| problem-forest-type stands. | completed in 1998. |
| 3 Not Satisfactorily Restocked (NSR) areas: assess and quantify into the THLB. | Application of the Inventory. |
| 4 Stand Tending: assess and quantify opportunities for stand tending. | Application of the Inventory |
| 4 Problem Forest Types: assess and quantify the size of the PFT. | Application of the Inventory. |
| 5. Roads, trails & landings: review and refine deduction (base mapping updates) factors. | Application of the Inventory. |
| 6 Regeneration, species conversion: assess and quantify extent of species conversion. | Application of the Inventory. |
| 8 Regeneration: assess opportunities for applying regeneration techniques. | Application of the Inventory |
| 7 Deciduous component: assess/quantify volume of deciduous within coniferous stands. | Application of the Inventory. |
| 8 Decay, waste, and breakage factors for balsam and cedar forest types may be underestimated. Complete factor review is required. | Phase II data will provide information on decay and waste. Estimates of breakage are not available. Cedar net volumes are an issue in this TSA. |
| 9 Alienation to agriculture types: assess reduction of land base. | Application of the Inventory. |
| 10 Alternatives to clear cutting: monitor use of alternative silviculture systems, mainly in mixed stands of lodgepole pine and Douglas- fir. | Application of the Inventory. |
| 11 Environmentally sensitive areas: assess feasibility of harvesting. | Application of the Inventory. |
| 12 Wildlife habitat: assess timber supply implications of wildlife habitat management under the CCLUP. | Improved Phase I estimates will provide additional information on delineating wildlife habitat and protected areas. |

## 2.3 Current Forest Cover Inventory

The Quesnel TSA was inventoried between 1963 and 1988, with an inventory update for all polygons completed between 1994 and 1995 (Quesnel TSA Inventory Audit Report). A few partial map sheets in the TSA are still identified as having a reference year from the 1978-1987 inventory period and Bowron Parks inventory is dated as pre 1960.

The inventory audit results for the Quesnel TSA indicated the following (from the Quesnel TSA Inventory Audit Report):

*The correlation coefficient of 0.518 for the audit and inventory estimates indicates a moderate*

*relationship among the individual samples. There is a 30m³/ha difference between the mean inventory estimate for mature volume (235m³/ha) and the audit estimate. A paired sample t-test determined that, for the mature component of the total forested area of the TSA, this difference is statistically significant 19 times out of 20. The 95% confidence interval for the mean paired difference is –57 to -3 m³/ha.*

Since there is a statistically significant difference between the two estimates, the ground attribute volume was calculated using the VDYP model. The estimated mean ground attribute volume is 211 $m^3$/ha. The difference between the mean ground attribute volume (211 $m^3$/ha) and the mean audit volume (205 $m^3$/ha) is 6 $m^3$/ha. The difference between the mean inventory volume (235 $m^3$/ha) and the mean ground attribute volume is 24 $m^3$/ha. This suggests that the majority of the bias in the volume estimates for the Quesnel TSA is associated with some of the inventory attributes.

The objective of the inventory audit in the Quesnel TSA was to assess the overall accuracy of the current Ministry of Forests inventory. The mature, immature, and non-forest components were tested.

Audit results for the mature component of the inventory suggest that the inventory volume is overestimated. Subsequent analysis of post-stratified data also shows a similar volume over estimation in the operable forested area.

Audit results for the immature component of the inventory suggest an acceptable level of accuracy for site index assignment in young stands.

### 2.4 Summary of Inventory Issues

A meeting was held in early May with Ministry of Agriculture & Lands – VRI staff (formerly MSRM) to develop business drivers for updated inventory information (presented in Appendix II). The following inventory issues (summarized) were identified by the stakeholders:

1. All forest stands require better species composition and height estimation.
2. The current forest inventory for the Quesnel TSA is complete for disturbance updates to 2002.
3. Inventory needs to be brought up to VRI standards.
4. Silviculture history and free growing information requires significant improvement.
5. Better quantify non-recoverable (gross) losses from insects, disease, and wind-throw.
6. Undertake forest inventory within provincial Parks and protected areas, as they contribute to seral stage balancing, old growth management, and habitat and rare ecosystem representation.
7. Improved species composition labels for deciduous and deciduous-coniferous mixed stands.
8. Undertake a site index adjustment project.
9. Confirm accuracy of loss factors and taper equations.
10. Assess wildlife habitat supply in the aftermath of the MPB epidemic.
11. The overall timber inventory appears to be over-estimated (inventory audit results).
12. Obtain and maintain a forest inventory to satisfy certification requirements.
13. Maintain inventory data in a consistent and accessible format.
14. Establish whether biophysical factors have an influence on the intensity of the mountain pine beetle infestation.

15. Projection of polygon attributes for mixed stands where 10 to 40% of the species composition consisting of Pl is expected to die.
16. Identification of dead Pl stands, health of young Pl stands, and an improved inventory in non-pine stands.

Inventory audit results aside, the general belief of the Quesnel TSA Stakeholder Group is that the forest cover inventory is dated, mainly because of the impact of the MPB infestation and in need of replacement. Specifically, the stakeholders require the following from a replacement inventory (VRI):

1. New 1:20,000 scale colour aerial photographs of the entire Quesnel Forest District including TFL's 5 and 52, and all parks and protected areas, for several purposes:
    a. salvage planning;
    b. mitigation planning (fertilization or other stand treatments (see 2 below));
    c. abandonment planning;
    d. forest health in managed stands;
    e. fire and/or fuel management planning;
    f. hydrologic studies and base enhancement; and
    g. maintaining habitat values and ecosystem representation.
    h. regeneration and stand tending planning

2. Inclusion of all parks and protected areas for 2005 aerial photo coverage and 2006 re-inventory as these areas contribute to seral stage balances and old growth management. Currently there is no useful inventory information available for parks in the Quesnel TSA
3. 
4. Improved harvest scheduling related to shelf life modelling and identification of stands containing >100$m^3$/ha.
5. Accommodating other resource values identified through a vegetation inventory (not a timber inventory as currently exists).
6. Improved species identification.
7. Improved stand structure identification, especially conifer understories.

## 2.5 VRI Activities and Products

The following VRI activities and products are needed to address the forest management issues identified for the Quesnel TSA. These recommendations are based on the issues identified in Table 3 and Section 2.3, including the discussions at the stakeholders meeting.

1. Acquire new photographs (scheduled for and hopefully completed in 2005).
2. Collect and update historical silviculture data, including correct positioning of external opening boundaries in softcopy.
3. Conduct a Phase I photo-interpretation for the entire Quesnel TSA. The Phase I database will support timber-emphasis inventories, habitat mapping, riparian mapping, salvage harvest scheduling, and other applications over the TSA.
4. Conduct Phase II timber emphasis ground sampling in the vegetated-treed areas of the Quesnel TSA, (excluding parks) to provide a statistically adjusted Phase I Inventory . These data will support the next timber supply review (TSR) in the Quesnel TSA in 2009.
5. In concert with the ground sampling, conduct Net Volume Adjustment Factor (NVAF) sampling to statistically adjust the volume attribute for hidden decay and taper equation bias. NOTE that NVAF is a required component of the inventory.

6. Monitoring activities around mountain pine beetle issues such as the establishment of random sample locations to evaluate regeneration success and track future stand dynamics.

# 3.0 STRATEGIC INVENTORY PLAN

## 3.1 Overview

This section outlines a preliminary strategic inventory plan to develop the specific VRI products discussed in Section 2.5. The VRI products include 1:20,000 colour aerial photographs over the entire Quesnel Forest District in support of a new spatial vegetation inventory (Phase I VRI) over the entire Quesnel TSA. In addition, conduct a timber emphasis sampling (VRI Phase II) program in the vegetated treed land base. These products can be obtained through completion of aerial photo acquisition, VRI photo interpretation, ground sampling, and statistical adjustment.

## 3.2 Photo-Interpretation (Phase 1)

### 3.2.1 Objective

The objective is to improve TSA polygon information − especially in areas where specific management issues occur − using photo interpretation. The Phase I VRI product is a spatial database consisting of unadjusted photo-interpreted estimates. Ground sampling, used to check and adjust the photo-interpreted estimates, is discussed as a separate process in section 3.3.

### 3.2.2 Target Area

The entire TSA should be updated to VRI standards through new photo interpretation (including woodlots, parks, and protected areas). Both TFL's in the Quesnel Forest District have completed operational VRI's.

### 3.2.3 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.

### 3.2.4 Methods

The Phase I inventory will be completed according to the most current MSRM standards using softcopy technology. While 1:15,000 scale colour aerial photographs are the preferred scale and emulsion to use for VRI with softcopy technology, the scale chosen for the TSA is 1:20,000, still a perfectly acceptable scale. The aerial photographs are intended to support multiple uses, including the creation of high-resolution orthophotos of the TSA as part of a TRIM II update project. As the images will be scanned and aerial triangulated already, viewer set preparation costs will be minimal. In support of a Phase I VRI in 2006, the desired understory attribute capture would be best facilitated with this scale of aerial photograph. As per current standards, air and ground field calibration will be established by the photo interpreters to gain local knowledge and improve VRI attribute estimation. In addition, conifer understories (especially

those under attacked pine stands), will be field calibrated.

The 1:20,000 color aerial photographs will enhance identification of species composition and forest health issues both in the mature forest (mountain pine beetle, balsam and spruce bark beetles, spruce budworm) and in the managed stands. In recent years, aerial photo scales of 1:30,000 to 1:40,000, using softcopy technology have been tested for VRI, as a cost savings. 1:30,000 scale photos are at the very upper limit for scale utility and only with panchromatic due to its improved resolution over colour. Scales smaller than 1:30,000 are not adequate regardless of emulsion for VRI and greatly reduce the ability to identify species composition, dead, gray stands and are even less useful in identifying the presence or absence of an understorey (let alone attributes associated with it), which will be critical in the aftermath of the mountain pine beetle epidemic.

The spatial quality assessment of the forest cover delineation has been included as part of this VSIP. Two map sheets were randomly selected, one from the western portion of the TSA to represent the more rolling terrain present there, and one from the eastern portion of the TSA to represent the more mountainous areas. The existing forest cover delineation was assessed in softcopy (DiAP viewer) for any evident spatial shift and applicability as foundation delineation for VRI. In the case of both test maps, the delineation was found, within the limits of forest cover delineation specifications, standards and vintage, to be well positioned to serve as foundation delineation for a Phase I VRI. No significant shift due to mapping was noted.

### 3.2.5 Costs

The aerial photography has been tendered and contracts awarded through the Base Mapping and Geomatic Services Branch (Air Photo and Lab Services) of Ministry of Agriculture and Lands (formerly MSRM). Costs for this project have not been made available at the time of preparation of this document, but are estimated at $325,000. An estimation of the cost of Phase I is not practical at this stage because of the uncertainty of completing the photography, scanning and triangulation.

The Phase I VRI costs will be more accurately determined once the exact parameters of the inventory are finalized, but based on an average TSA inventory (historical costs) with standard field visitation an approximate cost of between $0.90 and $1.10/ha. can be expected. If field visitation is increased, this cost per hectare estimate may increase. The are several non-traditional modelling options that can be considered, that in concert with a ‘continuous update’ process could see an initial VRI completed in a few months, with an annual and localized update and upgrade over a period of years. How the VRI Phase I is completed requires further discussion.

## 3.3 Enhanced Timber Emphasis Sampling – Vegetated Treed (VT) Land Base

### 3.3.1 Ground Sampling Objectives

The main objective of the timber emphasis sampling is to:

Install an adequate number of Phase II VRI sample clusters (enhanced timber emphasis including the collection of site series information) to statistically adjust the photo interpreted timber inventory attributes in the Vegetated Treed (VT) areas of the TSA, to achieve a sampling error between 10 and 15% (95% probability) for overall net timber volume in the VT area and

reasonably accurate individual polygon adjusted estimates, and to link mountain pine beetle infestation intensity to biophysical factors (if such a link exists).

Net timber volume is gross volume less stumps, tops, decay, waste, and breakage. Decay and waste will be estimated using VRI call grading/net factoring and NVAF sampling. Breakage will be estimated using existing loss factors. Strong arguments have been made against immediate NVAF sampling in areas hit hard by the mountain pine beetle epidemic and undergoing accelerated harvesting. The need for the NVAF phase of the VRI will be determined at a later date, after discussion with MAgL staff. The Phase II ground samples are used to statistically adjust age, height and volume attributes in the Phase I Inventory. The NVAF sampling statistically adjusts for hidden decay and taper equation bias.

Further to this there is also a need to identify deterioration rates with stand and site parameters for harvest scheduling reasons. Monitoring for the short term objectives is too slow so modelling using ground samples selected from matrix cells composed of permutations of time since attack, site, BEC zonation, etc… would address this. Remeasurement of PSPs within the TSA might prove useful for the fine-tuning of the matrix conditions. Estimates of net economic volume would be desirable as determined from VRI grading and net factoring of trees tallied in variable radius plots may be the best approach. An NVAF sampling could prove useful in the fine-tuning of this economic volume. The ultimate objective would be to determine which stand and site conditions were associated with a rapid decline in volume and grade vs. those that weren't.

### 3.3.2 Target Population

The target population will be the vegetated treed (VT) portion of the TSA located on crown land.

### 3.3.3 Sample Size

An estimated 100 sample clusters should be installed in the VT area. These samples would be distributed among leading-species strata proportional to their area, volume or some other criteria (Table 4). It has been suggested that at least some of the sample clusters (perhaps a redesigned plot configuration as well) be set aside as monitoring plots to collect more detailed information on mortality rates and be the basis for a re-measurement program to track regeneration and stand succession dynamics. The actual number of samples and their configuration will be determined with more precision in the sampling and monitoring VPIP.

**Table 4 Approximate Distribution of Plots by Leading Species**

| Leading Species | Area (%) | Volume (%) | Number of Plots |
|---|---|---|---|
| Lodgepole pine ** | 84 | 66 | 66-84 |
| Spruce (Sx) | 10 | 21 | 10-21 |
| Douglas-fir | 4 | 5 | 4-5 |
| Other * | 2 | 8 | 2-8 |
| **Total** | **100** | **100** | **100** |

* Aspen, sub-alpine fir, western redcedar, western hemlock, birch, cottonwood and larch
** The Pl stratum should be split into two strata (Pl $\geq$ 60 yrs and Pl <60 yrs), with a greater emphasis

on the younger stratum.

### 3.3.4 Sampling Approach

VRI Timber Emphasis Plots (TEP) should be used to gather data following the current VRI Ground Sampling Manual, or be modified as such to address the statistical adjustment of the photo interpreted inventory as well as both short and long term monitoring of regeneration and stand dynamics. These TEPs could provide a sampling framework for additional sampling, such as monitoring (where a subset of the TEPs would be re- measured over time).

### 3.3.5 Sample Selection

Sample polygons would be selected using the MSRM 'probability of selection proportional to size with replacement (PPSWR)' procedure. The selection process would follow the procedures outlined in the document, *Sample Selection Procedures for Ground Sampling v3.3*, December 2002, and the related document *Errata 1.0*, April 2005, or a more current version if one is made available when sample selection begins.

### 3.3.6 Net Volume Adjustment Factor Sampling

As per the MSRM standards, the net volume adjustment factor (NVAF) sampling is mandatory for the inventory. However, the sampling procedures allow for some flexibility around the timing of NVAF call grading and net factoring. 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; it will be used to statistically adjust the estimate of net merchantable volume of VRI ground samples.

The objective of the NVAF portion of the inventory is to complete destructive tree sampling and obtain local information for hidden decay, waste, and stem taper in order to statistically adjust the initial estimates of net volume.

For the ground sampling phase of the NVAF process, NVAF certified crews will provide detailed enhanced cruising (net factoring and call grading) of the trees selected for destructive sampling (live, dead, standing, or fallen) within the selected auxiliaries *immediately prior to* destructive sampling.

A minimum of 60 trees (50 live, 10 dead) will be selected from at least 17 VT auxiliary polygons. The finalized ground-sampling plan will provide additional details on stratification of destructive sampling plots.

NVAF, while not optional, may be delayed considering the mountain pine beetle epidemic and accelerated harvesting being conducted to mitigate the losses.

All NVAF planning and implementation will follow the Net Volume Adjustment Factor Sampling Standards and Procedures, MSRM, Version v4.0, March 2004.

### 3.3.7 Implementation

The implementation process will proceed based on available funding and can be implemented based on a number of scenarios. All implementation scenarios will follow a common process. One possible implementation process will proceed as follows:

1. Assemble all polygons within the District into one list; check to ensure no areas are missing or double counted.
2. Sort the polygon list according to the criteria: BC Land Cover Classification code, estimated leading tree species, age, and site index.
3. Select potential sampling points from the sorted list (see section 3.3.5).
4. Systematically select the 16 NVAF sample points (15 treed and 1 non-treed whether or not volume is indicated) from the Provincial Inventory ground samples.
5. Begin planning for field sampling.
6. Prepare a field sampling plan. Identify NVAF sample points and ensure they are field sampled early in the field season.
7. Locate and measure ground sample clusters.
8. Monitor quality assurance of field data and procedures during field sampling. Arrange for 'audit quality cruisers' to sample auxiliary plots of NVAF samples.
9. Compile the data including computing averages of timber volume, basal area, and regression of photo-estimated volume to ground sample volume and the associated standard error of the regression.
10. Prepare NVAF tree sampling matrix. Begin NVAF destructive sampling.
11. Compile all data, do the statistical adjustments, and load final inventory results into the provincial database.

A VPIP for ground sampling should be developed following MSRM guidelines in *Vegetation Resources Inventory Guidelines for Preparing a Project Implementation Plan for Ground Sampling*.

### 3.4 Costs

Costs associated with VRI Phase II include the VRI Phase II Sample Plan (~$8,000) and Phase II plot compilation and adjustment (~$10,000). Actual sampling costs are driven by plot access (truck vs. helicopter), but a reasonable estimate without knowing the plot distribution across the TSA would suggest approximately $1400 per plot plus approximately $17,000 for VRI Sample quality assurance auditing.

### 3.5 Monitoring

The Ministry of Forests and Range – Forest Analysis and Inventory Branch are responsible for monitoring this VRI planning process and ensuring that the final VSIP is approved.

## 4.0 APPROVAL/SIGNING

I have read and concur with the Quesnel TSA VSIP dated June 15, 2005. It is understood that this is an agreement-in-principle and does not commit the signatories to completing the inventory activities outlined within the plan. Modifications to this plan or more detailed plans need to be reviewed and approved by the signatories and then appended to this plan.

_____ per West Fraser Mills Ltd.

_____ per Canadian Forest Products Ltd.

_____ per Tolko Industries Ltd.

_____ per Quesnel Forest District (MoF)

_____ per Southern Interior Forest Region (MoF)

_____ per BC Parks Branch (MoE)

_____ per Ecosystems Section (MoE)

_____ per BMGS (MAgL)

# APPENDICES

# APPENDIX I – STAKEHOLDERS

List of Stakeholders in the Quesnel TSA.

| Licencees | Participant |
|---|---|
| West Fraser Mills Ltd. | Al Hunter |
| Canadian Forest Products Ltd. | Steve Day |
| Tolko Industries Ltd. | Wayne Boudreau |

| Agencies | Participant |
|---|---|
| MoF – Southern Interior Forest Region | Jim Grace |
| MoF Quesnel Forest District | Mike Pelchat |
| BC Parks Cariboo Region | Glen Davidson |
| MoE – Ecosystems Section | _____ |
| BMGS | _____ |

# APPENDIX II – Quesnel TSA Inventory Business Drivers

May 12, 2005

**Quesnel TSA - Business Drivers for Updated Inventory Information**

The Quesnel TSA has suffered extensive losses and damage due the effects of mountain pine beetle. It is projected that there will be substantial long-term impacts on timber supply and other forest values. Major forest licencees and the Ministry of Forests recognize that efforts must be undertaken to reduce or mitigate short-, mid- and long-term effects of the epidemic. We also recognize that there are major gaps in land-base information that is needed for planning purposes. The Quesnel group volunteered to participate in a pilot project that is, so far, undefined. The notes provide below are derived from recent discussions about business drivers and needs as we see the situation in Quesnel. Participants and contributors to the points provided below come from staff in government ministries and major licencees in Quesnel.

At the Provincial level, a project is underway to try and come up with an inventory strategy that addresses post-epidemic conditions. This project addresses timber and non-timber values. The pilot project being contemplated in Quesnel may serve to develop and refine the processes.

In the discussions in Quesnel, we recognized that there are other forest values other than timber that have been and are being affected by the epidemic. We generally limited our point of view to timber values, as that is what we have expertise in. Anything that we can do to mitigate the timber impacts will also have a beneficial effect on the community.

**A. Business Drivers**

**1. Harvest Planning and Scheduling**

1.1. salvage value and minimize economic losses from attacked pine
1.2. minimize rate of losses of pine to decay
1.3. balancing salvage planning (i.e. to avoid 'taking the best and losing the rest')
1.4. identifying areas to abandon with respect to sawlog harvesting opportunity

Inventory Needs

- Improve shelf-life estimates, including how it may differ in different BEC sub-zones and variants
- Derive estimates of timelines for development of factors which affect decline of wood quality, such as checking, drying, loss of bark
- Stratification of dead stands, damaged stands and green stands
- Ground sampling to quantify residual live volumes. .
- Determine areas where there is least value for timber and greater non-timber values, such as habitat or biodiversity, to support abandonment choices
- Updated photography or other imagery with a resolution useable for broad stratification and sampling, and for mapping OGMA's, MDWR, WHA's, or other biodiversity and habitat features.

**2. Mitigation of short- and mid-term losses of timber supply**

2.1. Bring mid-rotation stands to merchantable size in time to coincide with projected timber supply 'falldown'.
2.2. Improve estimates of growth potential on managed and unmanaged stands
2.3. Leave partially attacked stands for future harvesting opportunities

Inventory needs or information gaps

- Growth response of fertilizing in mid- or late-rotation stands, and when would fertilized stands reach merchantability, as compared to unfertilized stands.
- Stand selection criteria for mid- or late-rotation fertilizing
- Ground sampling to quantify ages and volumes of live residual trees in partially attacked stands
- Ground sampling to quantify understory coniferous density and growth rates in the various BEC sub-zones and variants (possibly to site series level)
    - Require species, densities, ages, heights, site index estimates
- Feedback mechanism to confirm or modify data derived from ground sampling.
- Photography or other imagery with a resolution useable for broad stratification and sampling.
-

(A PEM project for the Quesnel TSA will be completed in 2006; a site index project will be undertaken once the PEM is completed. Any adjustments to site index will be incorporated into the next TSR. This project supports item 2.2)

**3. Rehabilitation for long-term timber supply**

3.1. Prepare a rehabilitation strategy that would identify what can be done, where and what results would be expected.

3.2. Determine the potential to reclaim marginal or abandoned agricultural land as forest land.

## B. Non-Timber Considerations

**4. Habitat or Biodiversity Mitigation**

4.1. what are potential stand manipulation measures that may help create wildlife habitat?

4.2. what are the implications of the recent 'biodiversity uplift' in BEC sub-zones and landscape units.

4.3. what is the impact of pine mortality on terrestrial lichens in northern caribou habitat?

4.4. what is the condition of OGMA's, WTP's, RMA's or other biodiversity and habitat features after the MPB epidemic

4.5. how are 'indicator species' reacting to habitat changes resulting from the MPB epidemic?

4.6. should we re-evaluate how biodiversity can be measured in pine-leading areas, post-MPB epidemic

Needs

- participation of WLAP in planning
- new photography or imagery to assist in planning, ground sampling, and project work undertaken by government ministries and licencees related to both timber and non-timber values.

# APPENDIX III – GLOSSARY OF TERMS

**Ground Sampling:** Ground sampling is the field measurement of timber, ecology, range, and/or coarse woody debris values at one or more locations within each sample polygon. Sample polygons are selected using the probability proportional to size with replacement (PPSWR) method. To accommodate a wide variety of resources, various types and sizes of sampling units (e.g., fixed and variable plots, transects) are used to make the measurements.

**Inventory Unit:** An inventory unit is the target population from which the samples are chosen. The inventory unit could be a specific a geographic area (e.g. TFL or TSA) where a specific set of attributes is needed. The size of the inventory unit depends upon the sampling objectives.

**Land Cover Classification:** The BC Land Cover Classification Scheme (BCLCS) was designed specifically to meet VRI requirements, 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 land cover (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.

**Management VRI:** Management VRI are specialized inventories that provide detailed information required for specific resource management, i.e., day-to-day forest management. One or more VRI sampling procedures may be used for management inventories. Management inventories may focus on specific resource types (e.g., timber, range, ecology), geographic areas (e.g., landscape unit, TFL), attribute sets (e.g., Douglas-fir leading stands, age class 4+). They may use one or more of the following tools (e.g., photo-interpretation, ground sampling, NVAF sampling).

**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 estimated net volume is obtained from net factoring and taper equations). The NVAF (and VRI net factoring) replaces the existing loss factors for inventory applications. It does not, however, replace the loss factors for revenue applications.

**Photo-Interpretation:** Photo-interpretation involves subjective delineation of polygons and photo estimation of attributes for all polygons in an inventory unit. Medium scale aerial photographs (1:15,000 –1:20,000) are most often used in photo-interpretation. However, if existing photo- based inventory is acceptable, the database can be translated into VRI format and upgraded to include the additional VRI attributes.

**Post-Stratification:** Post-stratification involves dividing inventory units 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 to improve the precision of the inventory's overall averages and totals.

**Pre-Stratification:** Pre-stratification divides 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 special characteristics of each stratum.

**Resource-Specific Interpretations:** Resource-Specific Interpretations (RSI) use the Resource Inventory Committee (RIC) standard VRI baseline data products (provincial CMI or management inventory), in combination with other data sets and analysis (outside of that required to produce VRI), to produce information to address specific-resource management issues (e.g., TSR review, important ecosystems and habitats). These interpretations include ecosystem interpretations and habitat interpretations.

**Sample Size:** The sample size for an inventory is the minimum number of ground samples to be established in an inventory unit to meet the target precision.

**Statistical Analysis:** Statistical analysis or adjustment is the process of adjusting the values of the photo- interpretation variables using ground sampling observations. Ground observations are compared to photo-estimated values to develop adjustment factors by species groups. These factors are then applied to the polygons in the photo interpretation database to produce the final adjusted database.

**Sub-unit:** Sub-unit describes the inventory unit within an Inventory Unit. For example, if the inventory unit is defined as the Vegetated Treed area in a TSA, then a sub-unit may be defined by a specific geographic area (e.g., operable landbase) or stand type (e.g., problem forest types) within the Vegetated Treed area in the TSA.

**Target Precision:** Target precision expresses the amount of variation in key attributes (e.g., timber volume) desired in the final results. Target precision, usually expressed as the coefficient of variation (CV), is used to calculate the minimum sample size for subsequent ground sampling. The current target precision for timber volume is $\pm$10% (90% or 95% probability); stakeholders define the probability (uncertainty) level.

**Vegetation Resources Inventory (VRI):** VRI is an improved vegetation inventory process for assessing 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:

- **Photo-interpretation:** the delineation of polygons from aerial photography and the estimation of resource attributes;
- **Ground sampling:** the establishment of plot clusters in selected polygons to measure timber, ecological, and/or range attributes;
- **NVAF Sampling:** stem analysis sampling of individual trees for net volume adjustment;
- **WPV Sampling:** intensive sampling of selected polygons to determine the error between the estimated attribute values and the "true" attribute values; and
- **Statistical Adjustment:** the adjustment of the photo-interpreted estimates for all polygons in an inventory unit or management unit using the values measured during ground sampling.

The VRI can be deployed over the entire province measuring timber and non-timber resources, or over a large management unit (management VRI) measuring selected resources in specific portions of the landbase. 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.

**Within Polygon Variation Sampling:** WPV sampling provides information for expressing the true individual polygon error, assessed as the difference between the adjusted polygon value and the “true” value for that polygon. The “true” value for the polygon is an estimate derived from a small sample of polygons that are intensively sampled on the ground.

# APPENDIX IV – Quesnel TSA Map Sheet Area Summary

| Map Sheet | THLB Area (TSA) | Gross Area (TSA) | Park Area | TFL Area |
|---|---|---|---|---|
| 093A061 | 4,354.61 | 5,663.50 | | |
| 093A062 | 675.73 | 1,248.50 | | |
| 093A071 | 4,401.53 | 5,781.25 | 10.25 | 8,264.75 |
| 093A072 | 1,362.07 | 1,584.25 | | 8,784.10 |
| 093A073 | | | | 162.18 |
| 093A081 | | 435.00 | | 14,332.83 |
| 093A082 | | | | 14,302.88 |
| 093A083 | 34.03 | 81.25 | | 4,639.20 |
| 093A084 | 1,794.37 | 2,716.25 | 118.00 | |
| 093A085 | 427.59 | 2,069.00 | 143.25 | |
| 093A086 | 1,812.00 | 3,766.00 | 682.75 | |
| 093A087 | | 29.50 | 29.50 | |
| 093A091 | | | | 14,950.12 |
| 093A092 | 3,279.93 | 4,626.00 | | 10,238.99 |
| 093A093 | 1,733.61 | 4,602.25 | | 9,870.69 |
| 093A094 | 9,316.44 | 13,209.00 | 2.00 | 1,064.56 |
| 093A095 | 5,936.16 | 12,811.75 | 42.50 | |
| 093A096 | 3,909.22 | 5,132.25 | 43.75 | |
| 093A098 | | 5.50 | 5.50 | |
| 093B036 | 1,024.24 | 1,230.75 | | |
| 093B037 | 2,404.54 | 3,192.25 | | |
| 093B038 | 1,716.04 | 2,254.75 | | |
| 093B046 | 10,253.33 | 12,238.50 | 46.00 | |
| 093B047 | 10,460.95 | 13,739.50 | | |
| 093B048 | 8,278.06 | 11,872.75 | | |
| 093B049 | 2,876.19 | 4,170.00 | 42.00 | |
| 093B051 | 222.58 | 247.00 | | |
| 093B052 | 1,140.75 | 1,289.75 | | |
| 093B053 | 103.86 | 209.75 | | |
| 093B054 | 7,458.19 | 9,214.75 | | |
| 093B055 | 12,194.57 | 13,902.75 | | |
| 093B056 | 11,900.81 | 14,027.50 | | |
| 093B057 | 11,350.95 | 14,301.25 | 40.25 | |
| 093B058 | 3,254.74 | 12,293.75 | 7.00 | |
| 093B059 | 5,500.28 | 9,525.00 | 8.25 | |
| 093B061 | 5,854.29 | 6,549.00 | | |
| 093B062 | 10,845.55 | 12,974.75 | | |
| 093B063 | 9,001.26 | 11,491.50 | | |
| 093B064 | 11,358.21 | 13,703.25 | | |
| 093B065 | 11,847.26 | 13,760.75 | | |
| 093B066 | 11,832.59 | 13,639.50 | 232.00 | |
| 093B067 | 11,701.60 | 14,242.75 | 8.50 | |
| 093B068 | 2,567.56 | 11,124.75 | 253.25 | |
| 093B069 | 8,009.08 | 11,416.25 | | |
| 093B070 | 593.76 | 758.25 | | |

| Map Sheet | THLB Area (TSA) | Gross Area (TSA) | Park Area | TFL Area |
|---|---|---|---|---|
| 093B071 | 9,778.69 | 11,367.75 | | |
| 093B072 | 11,289.26 | 13,715.25 | | |
| 093B073 | 10,995.36 | 14,470.50 | 18.50 | |
| 093B074 | 11,313.55 | 12,874.75 | | |
| 093B075 | 12,205.38 | 14,292.00 | | |
| 093B076 | 12,506.29 | 14,297.25 | | |
| 093B077 | 11,897.66 | 14,661.75 | | |
| 093B078 | 1,578.70 | 9,709.25 | 411.75 | |
| 093B079 | 9,537.95 | 14,121.25 | 67.75 | |
| 093B080 | 8,639.19 | 12,628.00 | 129.75 | |
| 093B081 | 12,357.25 | 14,312.75 | | |
| 093B082 | 12,152.09 | 14,542.25 | | |
| 093B083 | 9,903.10 | 13,455.00 | | |
| 093B084 | 12,537.51 | 14,542.50 | | |
| 093B085 | 11,179.21 | 13,908.50 | 11.00 | |
| 093B086 | 10,751.88 | 13,305.25 | 11.50 | |
| 093B087 | 11,246.91 | 14,473.50 | | |
| 093B088 | 2,795.99 | 9,742.75 | 157.25 | |
| 093B089 | 7,984.21 | 12,513.00 | 51.25 | |
| 093B090 | 10,929.25 | 14,051.00 | | 94.42 |
| 093B091 | 11,801.01 | 13,894.75 | | |
| 093B092 | 11,196.37 | 14,059.25 | 85.25 | |
| 093B093 | 8,774.49 | 11,705.25 | 120.75 | |
| 093B094 | 12,673.40 | 14,271.50 | | |
| 093B095 | 10,742.13 | 13,395.25 | 54.00 | |
| 093B096 | 8,386.83 | 13,414.00 | 87.00 | |
| 093B097 | 7,646.00 | 13,927.50 | | |
| 093B098 | 1,021.37 | 8,449.00 | 564.25 | |
| 093B099 | 7,512.97 | 10,206.00 | 33.75 | 2,624.89 |
| 093B100 | 5,773.50 | 9,816.50 | | 4,360.14 |
| 093C070 | 904.86 | 1,045.25 | | |
| 093C075 | 2,680.84 | 3,338.50 | | |
| 093C076 | 368.67 | 2,830.25 | 1.00 | |
| 093C077 | | 233.50 | | |
| 093C078 | 6.05 | 6,900.25 | | |
| 093C079 | 3,110.42 | 9,101.50 | | |
| 093C080 | 9,905.01 | 11,689.25 | | |
| 093C083 | 1,094.99 | 2,112.75 | | |
| 093C084 | 489.29 | 10,248.00 | 2,765.75 | |
| 093C085 | 10,754.26 | 13,635.75 | 178.25 | |
| 093C086 | 9,337.56 | 12,828.50 | 31.50 | |
| 093C087 | 4,263.78 | 10,789.75 | | |
| 093C088 | 1,806.19 | 13,607.00 | | |
| 093C089 | 5,502.34 | 13,940.50 | | |
| 093C090 | 12,282.65 | 14,446.75 | | |
| 093C093 | 6,616.29 | 8,420.75 | 257.25 | |

| Map Sheet | THLB Area (TSA) | Gross Area (TSA) | Park Area | TFL Area |
|---|---|---|---|---|
| 093C094 | 5,108.07 | 11,269.50 | 281.00 | |
| 093C095 | 8,487.02 | 10,848.00 | 294.25 | |
| 093C096 | 10,489.63 | 12,858.50 | 144.50 | |
| 093C097 | 9,813.62 | 12,312.75 | | |
| 093C098 | 12,735.47 | 13,979.25 | | |
| 093C099 | 12,690.53 | 14,184.75 | | |
| 093C100 | 9,841.77 | 12,716.75 | | |
| 093F003 | 221.68 | 246.00 | | |
| 093F004 | 357.08 | 413.25 | | |
| 093F005 | 206.59 | 346.00 | | |
| 093F006 | 1,160.87 | 1,782.50 | 77.00 | |
| 093F007 | 8,545.11 | 11,289.50 | 428.25 | |
| 093F008 | 9,977.40 | 13,409.75 | 184.50 | |
| 093F009 | 10,004.77 | 12,069.50 | | |
| 093F010 | 10,735.73 | 12,646.00 | | |
| 093F017 | 57.90 | 126.25 | | |
| 093F018 | 491.51 | 1,713.50 | | |
| 093F019 | 4,474.60 | 6,838.00 | 29.75 | |
| 093F020 | 10,188.32 | 11,962.25 | 135.25 | |
| 093F029 | 1,316.71 | 1,526.75 | | |
| 093F030 | 6,338.61 | 9,577.25 | 1,934.50 | |
| 093F039 | 6,850.44 | 7,846.00 | 14.25 | |
| 093F040 | 10,250.43 | 13,697.25 | 45.50 | |
| 093F049 | 1,604.09 | 1,982.00 | 6.25 | |
| 093F050 | 3,682.98 | 4,141.00 | | |
| 093G001 | 11,552.06 | 14,074.25 | | |
| 093G002 | 11,040.53 | 13,861.75 | 2.00 | |
| 093G003 | 11,051.60 | 13,582.00 | | |
| 093G004 | 12,598.56 | 14,251.25 | | |
| 093G005 | 12,298.37 | 14,392.25 | 29.75 | |
| 093G006 | 11,626.52 | 13,965.50 | | |
| 093G007 | 5,838.60 | 12,014.00 | 24.25 | |
| 093G008 | 715.11 | 9,312.50 | 307.75 | |
| 093G009 | 1,750.61 | 6,304.25 | 12.00 | 7,577.44 |
| 093G010 | 7,552.41 | 9,605.00 | 5.25 | 4,640.20 |
| 093G011 | 9,922.92 | 14,241.75 | 2,487.00 | |
| 093G012 | 7,405.62 | 13,962.50 | 3,195.25 | |
| 093G013 | 11,230.37 | 14,089.50 | | |
| 093G014 | 13,082.46 | 14,726.50 | | |
| 093G015 | 11,378.67 | 13,681.00 | | |
| 093G016 | 11,184.94 | 14,127.00 | 123.25 | |
| 093G017 | 4,741.13 | 7,685.00 | 24.00 | 5,779.61 |
| 093G018 | 1,032.03 | 5,936.50 | | 1,571.20 |
| 093G019 | 109.08 | 1,110.25 | 32.50 | 10,639.38 |
| 093G020 | 1,203.01 | 1,344.00 | | 13,531.63 |
| 093G021 | 4,481.94 | 13,355.00 | 5,851.50 | |

| Map Sheet | THLB Area (TSA) | Gross Area (TSA) | Park Area | TFL Area |
|---|---|---|---|---|
| 093G022 | 8,573.84 | 13,134.25 | 154.25 | |
| 093G023 | 7,752.90 | 10,700.75 | 38.00 | |
| 093G024 | 10,746.81 | 12,397.50 | | |
| 093G025 | 6,366.72 | 11,133.50 | 47.50 | |
| 093G026 | 9,417.92 | 12,585.00 | | 1,236.52 |
| 093G027 | 1,005.86 | 1,320.50 | 39.25 | 5,474.13 |
| 093G028 | | | | 54.81 |
| 093G029 | | | | 399.46 |
| 093G030 | 552.63 | 613.25 | | 8,070.14 |
| 093G031 | 9,486.10 | 13,561.75 | 121.75 | |
| 093G032 | 9,371.26 | 12,154.25 | 109.75 | |
| 093G033 | 5,992.09 | 6,920.50 | 54.75 | |
| 093G036 | 227.21 | 271.75 | | 10,214.23 |
| 093G037 | | | | 7,319.97 |
| 093G040 | 2,189.73 | 2,785.25 | | 1,527.83 |
| 093G041 | 7,859.48 | 8,966.00 | | |
| 093G042 | 3,363.62 | 3,834.00 | | |
| 093G043 | 539.56 | 632.00 | | |
| 093G046 | | | | 2,149.39 |
| 093G047 | | | | 755.54 |
| 093G050 | 757.45 | 873.00 | | |
| 093H001 | 8,339.84 | 9,674.00 | | 4,417.21 |
| 093H002 | 6,126.42 | 9,619.50 | | 4,943.01 |
| 093H003 | | 995.50 | | 13,086.36 |
| 093H004 | 1,959.19 | 3,334.75 | 10.50 | 10,200.58 |
| 093H005 | 1,241.50 | 1,800.50 | 1.00 | 379.02 |
| 093H006 | 1.58 | 9.00 | | |
| 093H007 | | 38.50 | 38.50 | |
| 093H011 | 11,992.57 | 14,027.75 | 16.25 | 214.78 |
| 093H012 | 2,943.95 | 3,344.50 | | 11,483.34 |
| 093H013 | | 193.50 | 54.00 | 14,171.41 |
| 093H014 | | 13.25 | | 6,779.46 |
| 093H021 | 3,770.54 | 4,217.00 | | 10,439.51 |
| 093H022 | 379.38 | 421.00 | | 13,556.87 |
| 093H023 | | 402.00 | 11.50 | 13,045.43 |
| 093H024 | | 6.75 | | 2,051.79 |
| 093H031 | 2,867.90 | 3,490.75 | | 3,806.97 |
| 093H033 | | | | 3,987.31 |
| 093H034 | | | | 4,461.50 |
| 093H041 | 628.32 | 823.25 | | |
| **Total** | **1,010,901.07** | **1,422,122.25** | **23,118.75** | **291,655.78** |