Growing Forward

Nutrient Management Reference Guide

Canada - British Columbia Environmental Farm Plan Program

Delivered by:
BC Agricultural Research and Development Corporation

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CANADA - BRITISH COLUMBIA ENVIRONMENTAL FARM PLAN SERIES:

NUTRIENT MANAGEMENT Reference Guide

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The primary purpose of the Nutrient Management Reference Guide is to assist producers to develop Nutrient Management Plans for their farms.

While every effort has been made to ensure the accuracy and completeness of these materials, these materials should not be considered the final word on areas of practice that they cover. You should seek the advice of appropriate professionals and experts as the facts of your situation may differ from those set out in the materials.

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WHAT'S NEW

The following are highlights of the updates to the software and reference material since the October 2005 release of the Nutrient Management Planning subprogram of the Canada-British Columbia Environmental Farm Plan Program:

- Nutrient management planning software for forage crops using imperial units (in addition to a metric version)
- Support for field vegetables, raspberry and blueberry crops
- Ability to enter all laboratory report values on one (forage) or two (vegetable) worksheets
- Ability to compare soil test phosphorus and potassium results of different laboratory extraction methods
- Updated soil test ratings for phosphorus and potassium to better reflect soil test interpretations developed for British Columbia soils
- Updated factsheets and new factsheets on understanding different soil test methods
- "Agronomic Balance" and "Crop Removal Balance" concepts redefined to support decisions about nutrient optimization
- Ability to enter up to three manure sources per field
- Manure application rates are no longer automatically adjusted to use manure excesses (that are less than 10% of total manure production); instead, manure excesses/deficiencies or requirements are estimated by weight/volume for each manure type to be used and these are to be evaluated along with estimated nutrient balances
- Ability to enter nutrients from chemical fertilizers
- More accurate manure generation estimates for dairy farms: washwater and rainwater contributions to liquid manure handling systems are integrated into the spreadsheet
- Expanded and updated lists of book values for comparison with laboratory results – manure nutrient contents, ammonia retention factors (for manure spreading), and solid manure densities – see References for more information
- New assumptions about first-year nitrogen mineralization factors, nitrogen fertilizer credits from previous practices, and manure phosphorus availability – see References for more information
- Ability to generate printouts of field record sheets to compare actual nutrient application practices and expected yields with plans
- Software programs designed for Microsoft Excel 2007 and compatible with Microsoft Excel 2003.

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1 INTRODUCTION

The Nutrient Management Plan (NMP) in British Columbia has been developed as a subcomponent of the Environmental Farm Plan (EFP) process. This publication is part of the Environmental Farm Planning family of documents.

It is recommended that farmers first do an Environmental Farm Plan and then do a Nutrient Management Plan if directed to do so by the Environmental Farm Plan process.

Developing a Nutrient Management Plan is intended to help farmers optimize their nutrient usage, while protecting valuable soil, water, and air resources. In addition to the economic and environmental benefits, nutrient management planning is a valuable educational process that helps to ensure a farmer is in compliance with all relevant legislation.

This publication is intended for Planning Advisors and agricultural producers in British Columbia who want to do a Nutrient Management Plan.

OBJECTIVES OF NUTRIENT MANAGEMENT PLANNING

The core objectives of nutrient management planning are:

- to supply crops with nutrients at the appropriate rate, timing, and with the appropriate method to produce an economically optimal crop in terms of both yield and quality; and
- to minimize the risk of pollution by loss of nutrients via runoff, leaching, emissions to the air or other loss mechanisms

CRITERIA FOR DECIDING WHO WILL DO A NUTRIENT MANAGEMENT PLAN

Chapter 6 (Soil Amendments) of the **BC Environmental Farm Plan Reference Guide** deals most specifically with nutrient management issues and contains criteria for helping a farmer decide if a Nutrient Management Plan should be done on their farm. For producers in any of the following four situations, completing a Nutrient Management Plan is recommended:

1. Farms that may be out of Compliance with Nutrient Application Legislation. This applies to farms that answer “No” to any of the legislative questions on the Nutrient Application Worksheet in the EFP Workbook, and the proposed action is the development of a Nutrient Management Plan.

2. Livestock Producers and Producers of Intensively-Managed Outdoor Horticultural Crops Located over Moderately or Highly Vulnerable Aquifers that are Used for Drinking Water. Examples of such aquifers within the province include, but are not limited to, the Abbotsford-Sumas, Hopington, Grand Forks, Vedder River Fan aquifers and other aquifers referred to in Schedule 5 of the *Municipal Sewage Regulation.*

3. Significant Manure Nitrogen Generation or Use. Producers that generate or use manure should complete one of the following two assessments:

- **Screening Assessment 1 (EFP Workbook, Worksheet 4): A Manure Nitrogen Assessment for Farms that Generate Manure**, or
- **Screening Assessment 2 (EFP Workbook, Worksheet 5): A Manure Nitrogen Assessment for Farms that Use Manure as a Fertilizer** (but do not generate the manure)

The objective of the assessments is to determine if manure nitrogen utilization is above the values in Table 1.1 below. Farms that apply manure at rates below these values are considered to be at a low risk of causing pollution as long as the manure is being stored, handled and applied in compliance with the Code of Agricultural Practice for Waste Management.

Farms that apply manure at rates above these values may be managing their nutrients in full compliance with the *Code*, but the risk of over-applying nutrients and potentially causing pollution is higher. The actual risk would be specific to the farm being assessed, depending on a variety of factors including crops being grown, yield potential, topography, proximity to watercourses and climate. For farms that apply manure at rates above these values, a Nutrient Management Plan is recommended.

Table 1.1 Baseline Values Used for Assessing the Requirement for a Nutrient Management Plan

Crop Type	Baseline Manure Nitrogen Application Rate (kg N/ha/yr)*
Non-forage (e.g., berries, tree fruits, vegetables)	50
Forage grass (Fraser Valley)	300
Forage grass (rest of BC)	200
Forage corn	150

**Value based on Total Manure N*

4. High Soil Phosphorus. This applies if a farm is located in a phosphorus sensitive area (areas where surface water eventually flows to a lake or pond) and soil test phosphorus levels exceed 80 ppm in the 0 - 15 cm depth (by the Kelowna soil test method, for mineral soils). Phosphorus sensitive areas include, but are not limited to, the Okanagan Basin, Christina Lake Basin, Thompson River at Kamloops and other sensitive surface waters as defined by Schedule 5 of the *Municipal Sewage Regulation.*

In addition, livestock farms that have high soil potassium levels (above 300 ppm, Kelowna soil test method) or high forage potassium levels (above 3% on a dry matter basis) should consider developing a Nutrient Management Plan to minimize the impacts of potassium in their production system.

CONTENTS OF THIS PUBLICATION

This section summarizes the contents of each of the chapters in the publication.

Data Collection

Chapter 2 outlines the information that needs to be collected to develop a Nutrient Management Plan. In many cases, this information will be collected during the site visit that is done while developing an Environmental Farm Plan. In other cases a follow-up visit or phone call may be required. The data that is collected will later be used in the NMP software to assess current practices and make recommendations for future improvements.

Nutrient Optimization

Chapter 3 describes the steps to determine a strategy for how nutrients will be balanced. These steps involve determining a priority nutrient for each field or section of a farm that is to be managed separately and then applying concepts of agronomic and crop removal balances to meet production and environmental protection goals.

NMP Calculators

Chapter 4 serves as a user guide for the three NMP Calculator spreadsheet programs (Forage, Field Vegetables, and Berry). It outlines the steps used to make all the calculations necessary to determine appropriate rates and timing of nutrient applications for all the fields on a farm. There is information to support decisions to be made in the NMP Calculators and explanations of the results.

Assembling the Nutrient Management Plan

Chapter 5 provides suggestions on how to assemble the Nutrient Management Plan once all the calculations have been completed. This includes a suggested format for organizing the information and printouts into a binder.

Record-Keeping and Monitoring

Chapter 6 provides suggestions on how to set up a record-keeping and monitoring system. Record-keeping enables a producer to track actual nutrient management practices and increase production efficiencies over time. Monitoring allows a producer to evaluate the performance of the plan during and after the growing season during which the plan is made.

Nutrient Management Factsheet Series

Throughout the nutrient management planning process, there are references to recommended technical procedures that need to be done correctly to ensure the plan is as reliable as possible. These procedures, such as collecting representative soil samples and manure samples, are described in detail as stand-alone Nutrient Management Factsheets at the end of this publication.

LIMITATIONS OF THIS PUBLICATION

The general principles of nutrient management discussed in this publication can apply to all forms of agriculture where crop nutrients are applied to land. In British Columbia, the planning tools for nutrient management have been developed primarily for areas with intensive livestock production and areas of greater environmental concern. For example, raspberries and blueberries are grown on soils overlying the vulnerable Abbotsford Aquifer, which is also an area of intensive poultry production. Thus, greater effort has been dedicated to developing nutrient management planning tools for berry production since the first generation of nutrient management planning in the Canada – BC EFP program. Conversely, tree fruits in the Okanagan have not received the same attention to date partly because a soil nutrient survey in 2007 suggested post-harvest nutrient levels were lower in these crops.

As the science of nutrient management advances, further improvements will be made to the nutrient management planning process and additional cropping systems will be added to the suite included in this publication.

USE OF THIS PUBLICATION

Conventions and Acronyms

Measurements

- ac – acre
- ha – hectare
- imp. gallon – imperial gallon
- ppm – parts per million
- t – tonnes

Commonly used styles in this publication include the following:

- *Italics* – identifies a piece of legislation
- **Bold** – emphasizes particularly important information
- 🕮 – indicates a reference publication
- 💻 – indicates an interactive web site

Measurement Units

The nutrient management planning program was originally developed using the metric system and in some instances still use only metric units. Tables and examples for conversion to imperial units are provided, and at the time of printing, an imperial version of the 'Forage NMP Calculator' is available.

2 DATA COLLECTION

This chapter outlines the information that needs to be collected in order to develop a Nutrient Management Plan. In many cases, this information will be collected during the site visit that is done as part of developing an Environmental Farm Plan. In other cases a follow-up visit may be required. The data that is collected will later be used in the calculations that are performed to assess current practices and make recommendations for future improvements.

Table 2.1 summarizes the information needed for different cropping scenarios.

Table 2.1 Information required to complete a Nutrient Management Plan

	Forage	Field Vegetables	Raspberry Blueberry	No Land Application^
Field information	✓	✓	✓	
Soil tests	✓	✓	✓	
Crop or tissue tests	✓ †	✓ †		
Manure tests	✓	✓ *	✓ *	
Manure imports and exports	✓	✓ †	✓ †	✓
Livestock / animal information	✓			✓
Manure application method	✓ *	✓ *		
Manure storage system: other inputs	✓ †			
Grazing information	✓ †			

^ farms that generate manure and export all of it from the farm
* required if manure is applied
† optional: see details below

If there will be no land application of fertilizers or manure, the objective of the planning process is to document the amount of manure to be exported from the farm on which the manure is generated. The Forage NMP Calculator (Chapter 4) can be used with only the information required according to Table 2.1.

FIELD INFORMATION

For each field on the farm, information is needed on field size and field history.

For the purposes of a Nutrient Management Plan, a field should be a soil sampling unit identified by the following characteristics:

- It has the same cropping rotations, anticipated yields, and tillage
- It is normally no larger than 10 hectares (25 acres) in size. It can be larger if the characteristics and management of the field is known to be uniform from previous soil testing and records.

- It is the realistic area on which nutrients will be applied. If permanent setbacks are maintained adjacent to sensitive watercourses or wetlands, this area should be subtracted from the total acreage of the field.

Field history information should be provided for the 3 most recent cropping seasons. Factors to consider include the following:

- Fertilizer and manure application rates and frequency
- Cover crops, considering the presence of nitrogen-fixing legumes

SOIL, CROP AND MANURE INFORMATION

The nutrient balancing process requires information on soil nutrient reserves, manure nutrients, and anticipated crop nutrient uptake. This information requires collecting and submitting representative soil, manure and crop samples to a laboratory for analysis.

If sampling protocols used differ from those in the sampling factsheets, this information should be included along with laboratory reports in the Nutrient Management Plan.

Soil. A representative soil sample should be collected from each field. Following laboratory analysis, the soil test values will be used as a snapshot of available nutrient levels in the soil and to determine what level of additional nutrients may be required. See guidelines in **Factsheet 2**.

Crop. For each crop grown, the anticipated crop yield should be identified. Where accurate records have been kept, it is best to determine yield based on historical on-farm yields. As yields fluctuate from year to year, it is recommended to take the average yield for the past 3 to 5 year period. If on-farm records are not available, local historical yield averages may be available from the regional agrologist in the area or from other local industry experts.

With **forage crops**, an analysis of forage quality for protein, phosphorus and potassium content is recommended. Book values are provided for reference; it is recommended that farm or field-specific values will be taken. See guidelines in **Factsheet 4**.

With **field vegetables**, usually only a portion of the crop is harvested. By default, book values are used in the Vegetable NMP Calculator for several crops, and crop tissue analysis of the harvested portion can be used to get farm or field-specific values to assess crop removal.

With **raspberries**, a visual assessment of primocane vigour is used instead of crop tissue testing. This assessment is best done in the fall. The farmer and Planning Advisor should subjectively rank the vigour as excessive, normal or weak, based on the primocanes' appearance: thicker canes, longer canes, more canes and darker green shades indicate greater vigour.

Tissue testing can also be done to assess whether there are deficiencies or surpluses of nutrients. This approach is more advanced with some crops than others and it is currently beyond the scope of the Nutrient Management Plan.

Manure. If manure is generated or land-applied on the farm, a representative manure sample should be collected and analyzed for nutrient contents for each manure storage facility that provides manure to be applied. See guidelines in **Factsheet 5**.

The items identified below are the requirements (and recommendations where noted) to use the NMP Calculator software:

Soil Analysis

The following soil tests should be included for a spring soil sample (0-15 cm) for **forage** and **field vegetable** crops.

- available phosphorus (P)
- available potassium (K)
- nitrate-nitrogen (NO_3-N)
- ammonium-nitrogen (NH_4-N) – recommended
- pH – strongly recommended if soil pH has not been measured in the last three years or if the Planning Advisor is uncertain if pH is less than or greater than 7.2

The following soil tests should be included for **raspberries** and **blueberries**:

- available phosphorus (P), sample depth (0-15 cm)
- available potassium (K), sample depth (0-15 cm)
- post-harvest nitrate-nitrogen (NO_3-N), sample depth (0-30 cm), ***raspberries*** *only.* Soil samples should be taken after crop harvest between approximately August 15th and September 1st. A spring soil test is not used to assess nitrogen fertility levels of a raspberry field.

The Planning Advisor should note the extraction methods used for soil test phosphorus and potassium (as described in Factsheets 1, 2 and 3).

Crop or Tissue Analysis

- crop protein or nitrogen content (N)
- crop moisture content
- crop phosphorus content (P)
- crop potassium content (K)

For forage crops, it is strongly recommended that farm or field-specific values are used from averages over recent years if not from the previous year.

For field vegetables, average N, P and K contents of many crops are provided in the NMP software. Tissue testing of the plant material that is harvested will give farm or field-specific values.

For average N, P and K content of crops not listed in the NMP software, go to the USDA **Crop Nutrient Tool** at http://plants.usda.gov/npk/main

For berries, tissue testing is not part of the nutrient management planning process at this time. Crop tissue testing for these crops has been developed outside of BC but because applicability to local conditions is unclear, the following resources are provided for interest only at this point:

- **Caneberries Nutrient Management Guide:** available on the http://extension.oregonstate.edu/catalog/html/em/em8903-e/
- **Nutrient Management for Blueberries in Oregon:** available at http://extension.oregonstate.edu/catalog/pdf/em/em8918.pdf

Manure Analysis

- total nitrogen (N or TKN)
- ammonium nitrogen (NH_4-N)
- nitrate-nitrogen (NO_3-N) – optional for composts
- total phosphorus (P)
- total potassium (K)
- total solids or dry matter (TS or DM), or moisture (MC)

Frequency of Sampling

The quality of a Nutrient Management Plan depends in part on how realistic the values are for the soil, crop and manure analysis. Ideally, analysis will be based on samples collected in the current year, particularly the first time a Nutrient Management Plan is being done.

In subsequent years, the following sampling frequency is recommended.

Soils

- at least every three years
- more frequent sampling is recommended if the soil is coarse-textured or if crops have been grown that are heavy users of nutrients
- annual pre-sidedress (mid-season) and post-harvest soil nitrate testing is recommended for certain cropping situations – see Chapter 6: Record Keeping and Monitoring

Crops

- for each harvest in the first year of the plan
- if numbers appear stable, reduce frequency in future years

Manure

- at least once a year
- more frequent sampling is recommended if moisture content changes significantly throughout year – typically at least one sample to represent spring applications and one for summer applications
- if values appear stable after 2 to 3 years of sampling, reduce frequency

Manure Imports and Exports

Estimate the volume of manure that will be imported to the farm and exported from the farm on an annual basis. If the manure imported is significantly different from other manures being managed on the farm, a manure nutrient analysis is also recommended.

For operations that transport manure on or off the farm, this information is used to account for the movement of nutrients contained in this manure.

For **field vegetables and raspberries/blueberries**, the volume of manure does not have be estimated during the data collection phase if it is a value that will be determined using the NMP Calculators and included in the Conclusions and Recommendations of the Nutrient Management Plan.

LIVESTOCK / ANIMAL INFORMATION

For livestock and poultry farms, an inventory of the number of animals of each type should be collected. If the numbers fluctuate during the course of the year, the average number should be used. For each livestock group, state whether the manure is handled as a liquid or solid.

For dairy animals, also specify the numbers by age group, the breed and average milk production per milked cow if available.

This information will be used to estimate the volume of manure that is generated on the farm.

MANURE APPLICATION METHODS

Manure spreading practices and soil and weather conditions affects the ammonia (nitrogen) loss during and after manure application.

Find out what manure spreading equipment is used, at what times of year manure is typically applied, and typical spreading rates.

INFORMATION FOR ESTIMATING OTHER INPUTS TO MANURE STORAGE SYSTEM

This information is used primarily for dairy farms, and is used to best estimate volumes of rainwater, washwater and other possible inputs into a manure storage system. Information that needs to be collected includes the following:

- Dimensions of all unroofed manure storage facilities
- Dimensions of all outside yard areas from which runoff drains into manure storage facilities
- Dimensions of all roofs from which runoff enters manure storage facilities
- If a solid/liquid separator is used, an estimate of the percentage of the total liquid manure volume that is diverted to the solid manure volume.
- For dairy systems, a measurement of daily milkhouse and parlour washwater usage. The following tips can help with this estimate.
    - For pipeline washing, determine the volume of water used per wash or rinse cycle and multiply by the number of cycles run per 24 hour period.

- For bulktank washing, determine volume of water used for all wash and rinse cycles for every milk pickup cycle. If milk is picked up every second day, divide estimate by two.
- For estimating washwater used to hose down the parlour or holding areas, measure how long it takes to fill a bucket with a known volume, then multiply the flow rate by the estimated time spent conducting washdown activities per 24 hour period.
- If any washwater is collected and reused for other washdown processes, be sure not to count this volume twice.

▶ For all systems, an estimate of the volume of any other inputs, either liquid or solid, that enter the manure storage facilities. Examples of such inputs are silage effluent, spoiled feed, and other washwater.

Combined with the livestock information, this information produces estimates of liquid and solid manure (and waste) volumes and weights to determine if there is an excess or deficiency compared to land application requirements.

GRAZING INFORMATION

This information is currently used for dairy farms only. Since grazing animals do not contribute manure to the manure storage system while on pasture, the estimated number of days the dairy cattle graze is used to deduct the daily volume of manure generated by these livestock during the grazing period.

3 NUTRIENT OPTIMIZATION

A successful Nutrient Management Plan accomplishes two objectives:

- determines how to provide nutrients at the appropriate rate, timing, and with the appropriate method to produce an economically optimal crop in terms of both yield and quality
- minimizes the risk of causing pollution by loss of nutrients via runoff, leaching, emissions to the air or other mechanisms

This chapter defines the Agronomic Balance and Crop Removal Balance concepts. These concepts, when applied together, help determine appropriate nutrient application rates to help meet the above two objectives.

The three nutrients that are central to the Nutrient Management Planning process are nitrogen, phosphorus, and potassium.

DEFINITIONS

For the purposes of this planning process, the following definitions are used:

Crop Nutrient Uptake: the amount of a nutrient that is predicted to be taken up by a crop (assuming all other related requirements are met) in a one year period.

Crop Nutrient Recommendation: the amount of plant available nutrient recommended for a crop on an annual basis to produce an economically optimal and environmentally sustainable yield.

Crop nutrient recommendations are generally determined by subtracting the amount of a nutrient estimated to be available in the soil from the predicted crop nutrient uptake. The calculation includes an estimate of the amount of soil organic nitrogen that will be released into plant-available forms over the course of the growing season (e.g. by mineralization).

Crop nutrient recommendations for phosphorus and potassium depend on soil test results and the crop. For field vegetables and berries, crop phosphorus and potassium recommendations come from the most current BC-based soil test interpretation guidelines. For forage crops, crop phosphorus and potassium requirements in this planning process are similar to but not identical to these guidelines.

📖 **Interpretations for Soil Test Phosphorus and Potassium: Guidelines for Southern British Columbia**

Agronomic Balance: the crop nutrient recommendation minus the amount of the available nutrient from all nutrient sources (manure and commercial fertilizer) in the year of nutrient application.

Negative agronomic balances indicate situations where the planned application rates would likely provide more available nitrogen, phosphorus or potassium than the crop requires in the year of application. The current nutrient management planning process provides annual agronomic balances. A longer-term agronomic balance would require a modified definition.

Crop Removal: the amount of a nutrient removed from the crop at harvest.

Crop removal depends on the yield of a crop as well as the amount of a nutrient per unit weight of the harvested portion of the crop. Crop removal estimates do not depend on soil test results (although in reality, crops can take up nutrients in 'luxury' amounts in some cases of high nutrient levels).

Crop Nutrient Factor: the amount of a nutrient per unit weight in the harvested portion of a crop.

In the current nutrient management planning process, crop nutrient factors are used to estimate crop removal for all crops except berry crops (for which crop removal occurs but is not being estimated at this time).

Crop Removal Balance: the crop removal of a nutrient minus the total amount of that nutrient from all nutrient sources that are added to the soil, over a certain time period. For the current planning process, the time period is one year. A longer-term crop removal balance would require a modified definition.

This crop removal balance concept assumes that all of the nitrogen, phosphorus and potassium that is added to the soil eventually becomes potentially available to plants. Negative crop removal balances indicate situations where inputs of a nutrient exceed the outputs, and the difference is the amount that is left to accumulate in the soil or be lost to the environment.

BALANCING NUTRIENTS: THE PRIORITY NUTRIENT

This section outlines a general process for determining appropriate nutrient balances for each field (or part of a field) of a farm, using the terms defined in the above section.

The Priority Nutrient

Selecting appropriate application rates begins with identifying the priority nutrient for each section of the farm for which a soil test is taken. The Planning Advisor should give priority to a specific nutrient to target for optimization in the Nutrient Management Plan. Both crop production and environmental factors need to be considered in this decision. In some cases, a farmer may choose to optimize for one nutrient on one field and another nutrient on other fields.

The concept of priority nutrients becomes practically important when animal manures are used. The ratio of nitrogen to phosphorus to potassium present in manures is seldom balanced with the ratio required by most crops, especially when potential loss and availability factors are considered, so it is difficult to balance all nutrients with crop requirements using only manures. In most cases where potassium or phosphorus are selected as the priority nutrient, the farmer will be challenged to supply enough nitrogen for crop growth. Nitrogen deficits may be best managed by conserving nitrogen in manure and using supplemental nitrogen fertilizer.

The following criteria are suggested to assist the Planning Advisor and farmer in selecting the priority nutrient:

1. **Dairy or beef operations:** manage manure application based on **potassium** if soil potassium is over 300 ppm (Kelowna soil test method, 0-15 cm sampling depth). If under 300 ppm go to (3).
2. **Non-cattle operations:** manage manure application based on **potassium** if soil potassium is over 400 ppm (Kelowna soil test method, 0-15 cm sampling depth). If under 400 ppm go to (3).
3. Manage manure application based on **phosphorus** if field runoff or erosion might enter a phosphorus sensitive environment. Generally phosphorus sensitive environments are located where runoff water enters lakes in the interior of BC. If suitable buffers are utilized and no runoff reaches the watercourse or if not in a phosphorus sensitive environment go to (4).
4. Manage manure application based on **nitrogen**.

Agronomic and Crop Removal Balances

For raspberries and blueberries, the nutrient management planning process currently provides only agronomic balances.

For forage and field vegetable crops, agronomic balances are considered first and then crop removal balances in the following manner:

1. If the priority nutrient is potassium or phosphorus and the agronomic balance for the priority nutrient is negative, evaluate the crop removal balance for the priority nutrient. If the crop removal balance is negative, then aim to decrease the nutrient application rates to reach a crop removal balance of zero for the priority nutrient.

   These situations indicate high soil potassium or phosphorus levels, and the Planning Advisor should provide advice to reduce build up of potassium or phosphorus in soils of highest risk.

2. Planning Advisors should aim to keep all nutrient application rates at or below the the agronomic rate for nitrogen, such that agronomic nitrogen balances are not negative.

4 NMP CALCULATORS

This chapter is essentially a series of user guides for using the **NMP Calculator** suite of spreadsheet programs to assist with developing a Nutrient Management Plan. This suite consists of three separate programs:

- Forage NMP Calculator – p. 18
- Vegetable NMP Calculator – p. 27
- Berry NMP Calculator – p. 32

Detailed instructions are contained within each spreadsheet program. This chapter provides a concise overview of how the steps within each program link with each other. It also provides help for making decisions and tips to solve common problems that are particularly useful to first-time users.

The following objectives will be met to varying degrees depending on the program used:

- determine crop nutrient recommendations
- estimate available nutrient supply from soil and manures
- determine optimum time, rate and method of manure application
- determine appropriate amount of supplemental fertilizer to be applied, if required

Various assumptions have been made to simplify the process. In reality, nutrient cycles are quite complex and predicting the availability of manure nutrients is not an exact science. Nevertheless, following a systematic process as outlined in this chapter will help to generate a reasonable plan. The results should be considered to be part of a strategic plan: the nutrient management plan is forward-looking and relatively long term. After a plan is complete, short term decisions are made that ideally will be consistent with the plan but ultimately must reflect conditions in the field as they happen. Records of these decisions are backward-looking and are meant to be used to improve assumptions for updating the nutrient management plan. Chapter 6 addresses record-keeping and monitoring.

The steps and examples used in this chapter are oriented towards nutrient management in **forage crops, field vegetables,** and **raspberries and blueberries**. A modified process would be used for determining crop nutrient requirements for other crops. At the time of printing, processes for other crops was still under development.

BEFORE YOU BEGIN

Data Collection

Collect the necessary information to enter into the programs, according to instructions in Chapter 2. With this information, you should be able to, but are not expected to, complete the summary sheet (Figure 4.2).

About the NMP Calculators

System requirements: Microsoft Excel 2003 or newer. The NMP Calculator suite of programs was developed for Microsoft Excel 2007 and is compatible with Microsoft Excel 2003.

It is assumed that users have a basic understanding of Microsoft Windows and Excel, including how to copy and rename files. Regardless of which NMP Calculator program you use, the **first thing you should do** is to make a copy of the spreadsheet program with a new filename and keep a copy of the original spreadsheet program.

All of the NMP Calculator programs share the following features:

- Users should have to **fill in only cells that are shaded light yellow**.

Table 4.1 Colour scheme in NMP Calculator programs

yellow	user enters a value (in some cases from a drop-down list)
purple	no change necessary, usually a title or heading
grey	no change necessary, a calculated or blank value
blue	no change necessary, a calculated value

- Worksheets are protected to help prevent accidental changes to formulas that should not change in most cases.
- Macros need to be enabled. Depending on the security settings in your version of Microsoft Excel, users may see a security warning like those in Figures 4.1a and 4.1b and should choose the option to **enable macros**.

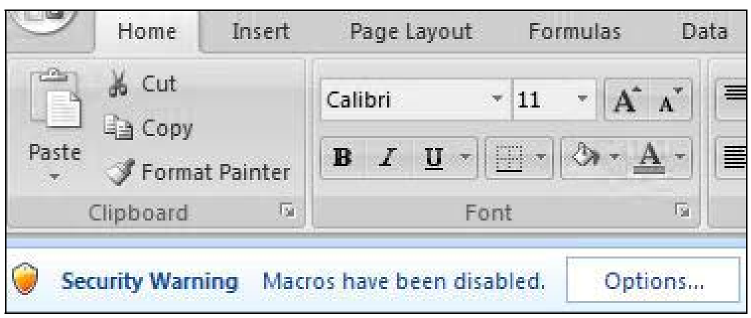

Figure 4.1a. Prompt to enable macros in Excel 2007

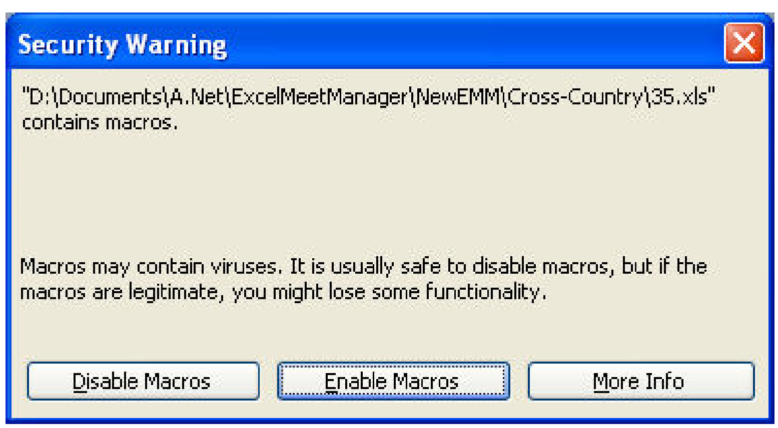

Figure 4.1b. Prompt to enable macros in Excel 2003.

Figure 4.2

SUMMARY SHEET FOR SOIL, PLANT, AND MANURE ANALYSIS INFORMATION - EXAMPLE

General Farm Information: (type of livestock, number of animals)

Soils information:

Field	History	Spring soil sampling and analyses		
		Nitrogen (as nitrate-nitrogen ppm NO_3-N)	Phosphorus[a] (ppm)	Potassium[b] (ppm)
[a] Lab method for phosphorus:		[b] Lab method for potassium:		

Crop information:

Field	Crop type to be fertilized	Field size (ha)	Manure and fertilizer history	Historical crop yield and analyses			
				Dry Matter yield	Protein or N (%)	Phosphorus (%)	Potassium (%)

Manure information:

Manure source	Description	Manure sampling and analyses			
		Total nitrogen (kg N/t)	Ammonium - nitrogen (kg NH_4-N/t)	Phosphorus (kg P/t)	Potassium (kg K/t)

Comments on manure management practices:

FORAGE NMP CALCULATOR

The Forage NMP Calculator will help meet the following objectives:

- determine forage crop nutrient recommendations
- estimate available nutrient supply from soil and manures
- determine appropriate amount of supplemental fertilizer to be applied, if required
- determine optimum time, rate and method of manure application

Figure 4.3 is a flowchart that gives an overview of how the worksheets of the Forage NMP Calculator link with each other. When the program is opened in Excel, the user completes the worksheets from left to right – beginning with the Quick Fill worksheet and ending with Worksheets 9a and 9b, as shown in the flowchart. Each worksheet is completed from top to bottom.

- On worksheets with field-specific data, the data for up to 16 fields is shown on the same worksheet.

More detailed explanations about how the program works and the calculations in each worksheet are in the program itself and are not repeated here. Instead, this section provides support for those steps where the Planning Advisor needs to make decisions about what data to enter. These steps are marked in the flowchart by parallelograms and diamonds and are discussed below according to the worksheet. The outputs are marked in the flowchart as rectangles.

QUICK FILL WORKSHEET FOR WORKSHEETS 1 TO 5

The Quick Fill worksheet is an optional form that allows the user to enter all laboratory data in one worksheet and then click a button to copy this information into Worksheets 1 to 5. If Quick Fill is not used, the user will enter the data directly into Worksheets 1 to 5.

Enter field information and data from soil tests, crop tests and manure tests. Having good data from the laboratory analyses is crucial to producing reliable estimates of manure and fertilizer requirements. Here are some tips and questions to ensure you are entering good laboratory data:

- Check the data as soon as you get results. If confidence in the data is low, you may be able to have the laboratory reanalyze the sample(s) before the laboratory disposes of them. Alternatively, you may decide to take another set of samples for analysis if time permits.
- Compare the laboratory values for crops and manures with book values. Although nutrient contents of these materials vary from farm to farm, they should be reasonably close to the book values provided in the program. If they are not and there is a reasonable explanation for the difference, be prepared to explain the difference.
- continued on page 20

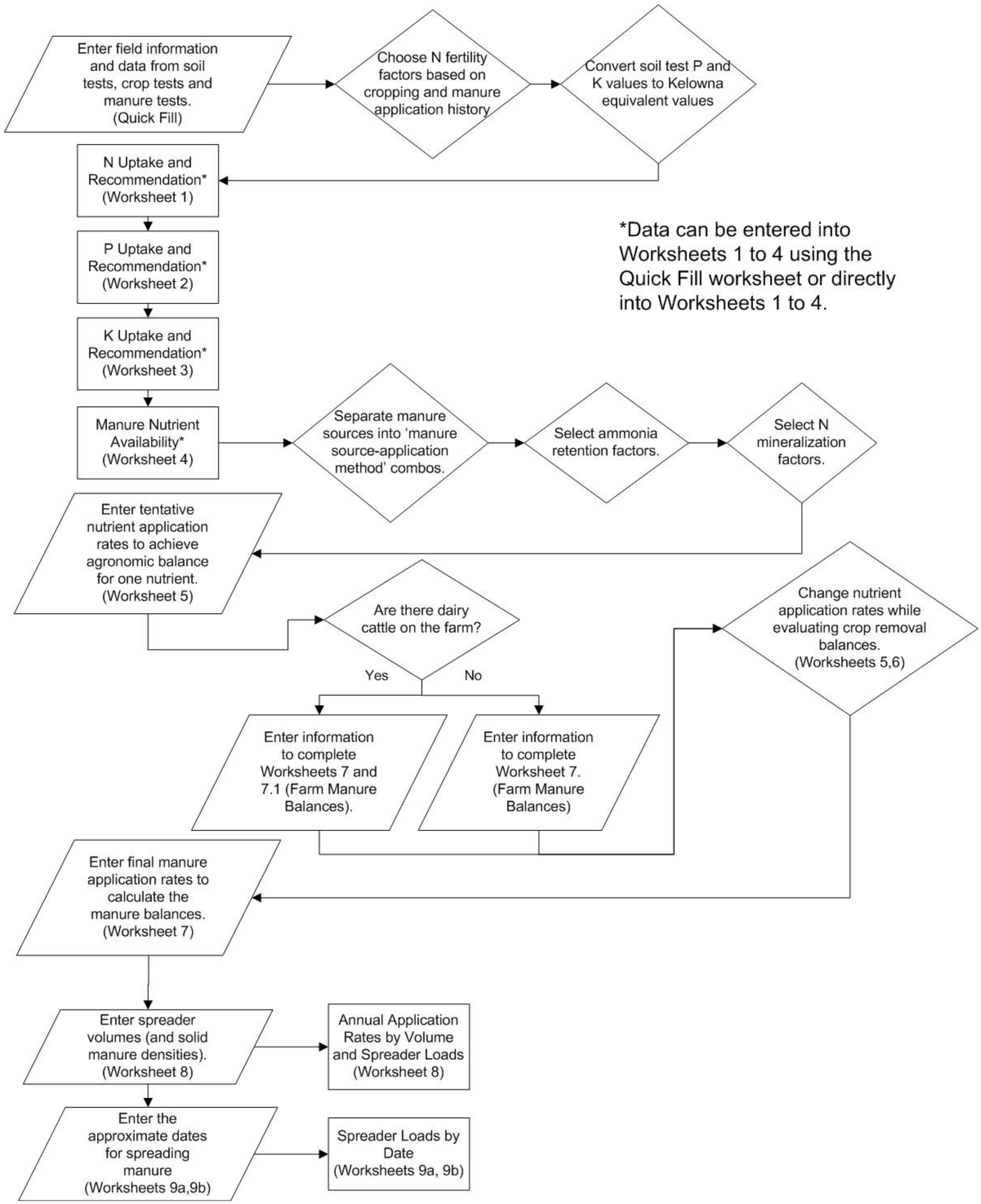

Figure 4.3. Flowchart overview of process for completing worksheets in Forage NMP Calculator

Here are some more tips and questions to ensure you are entering good laboratory data (continued from page 18):

- Use manure nutrient values that represent the manure that will be applied. Nutrient concentrations (on a fresh weight basis) for liquid manures increase with decreasing water contents, so using laboratory analyses from spring and summer manure samples will likely produce more reliable estimates than from a single manure sample.
- Are the data in the same units as those required in the program? Use book values and conversion factors in the program. Note whether phosphorus is given as P or P_2O_5 and whether it is K or K_2O.
- Are soil test P and K ratings consistent with the P and K ratings of the forages? Low soil values and high forage values, or vice versa, may indicate an error in the sampling or analysis.
- Are soil test P and K ratings consistent with previous results? Dramatic changes in these nutrients from one year to the next are unusual in typical cases, as are sudden departures from year-to-year trends in levels of these nutrients.
- If soil test values are reported as a range (e.g. "> 60 ppm"), ask for the soil sample to be reanalyzed and the result to be reported as an absolute value.
- If there is no confidence in using the laboratory results, consider using historical data and book values if available until samples can be retaken according to **Factsheets 2, 4 and 5** for sampling guidelines. Keep notes about sampling protocols and environmental conditions around the time of sampling that may explain discrepancies between expected values and laboratory results.

Choose N fertility factors based on cropping and manure application history. This is one of the steps in the planning process with least certainty. The actual nitrogen credits from historical practices will vary with the practices as well as the conditions (e.g. soil moisture and temperature) that are more difficult to predict. The Planning Advisor has the flexibility to change nitrogen credits according to the following principles:

- Nitrogen fertility factors can probably be increased to 150 kg N/ha (130 lb N/ac) or greater if organic matter content in the top 20 cm of soil is greater than 5% and forage crops have been fertilized with manure every year for the past five years.
- If legumes (e.g. alfalfa) will be part of the stand and their roots are nodulated (indicating they can 'fix' nitrogen from the air), increase the nitrogen fertility credit in proportion to its density in the stand up to 150 kg N/ha (130 lb N/ac). Although legumes will use nitrogen from manures and other soil amendments, most of this nitrogen is not necessary, will decrease the ability of the legumes to fix their own nitrogen and may increase competition from weeds and grasses.

Convert soil test P and K values to Kelowna equivalent values.

- If the soil test P method used is bicarbonate (i.e. Olsen method), you will most likely choose the bicarbonate-**colorimetry** method for converting the value to the Kelowna method equivalent. Most commercial laboratories use colorimetry for bicarbonate; you can confirm with the laboratory that you use. This conversion has the least certainty of the conversions provided.

- Pick the proper method. Some laboratories analyze and report soil P values using multiple methods.

📖 **Nutrient Management Factsheet Series #1: Nutrient Testing Laboratories**

📖 **Nutrient Management Factsheet Series #3: Understanding Different Soil Test Methods**

Worksheet 4: Manure Nutrient Availability

Separate manure sources into manure source-application method combinations. If you used the Quick Fill worksheet, you entered manure sources (e.g. liquid dairy manure). Because of the high variability in nitrogen losses under different manure spreading conditions, it is important to try to account for the most probable situations. In this worksheet, make a separate and well-described line entry where any of the following combinations of conditions may vary:

- manure type – dairy, hog, poultry, etc. and liquid or solid
- manure application method – splash plate, injection, SSD, etc. or time between application and incorporation
- time of year – spring versus summer

Select ammonia retention factors. This is directly related to the manure application method and climatic conditions expected at the time of manure application. Use the ammonia retention factors in Tables 7a-d, or use the Ammonia Loss Calculator for liquid dairy and hog manure to vary the factors that affect ammonia loss from spreading these manures: http://www.farmwest.com/index.cfm?method=climateammonia.showgraph The percent manure that is not lost is assumed to be the percent retained.

Select N mineralization factors. See Table 6 in the worksheet for help.

Worksheets 5, 6 and 7: Agronomic, Crop Removal and Manure Balances

Deciding what data to enter into Worksheets 5, 6 and 7 is like juggling a need to balance nutrients according to agronomic and crop removal balances and a need to use the manures generated on (and imported to) the farm. The greater the surpluses of manure, indicated by negative manure balances, the more complicated is the juggling act. The process attempts to select nutrient application rates to achieve the following objectives:

- Maximize beneficial use of manure generated on the farm.
- Meet nutrient recommendations and avoid negative agronomic balances.
- If negative agronomic balances cannot be avoided, minimize the magnitude of negative crop removal balances and allocate manure application to fields according to the priority nutrient for each field.
- Determine how much of the farm's manure supply can be utilized by the application rates selected.

1. Enter tentative application rates for each manure source-application method and fertilizers including desired amounts of starter fertilizer (Worksheet 5).

- Choose the highest application rates of manures to achieve an agronomic balance (indicated by a value of zero) for one nutrient without creating negative balances for the other two nutrients. In most cases, you will start by achieving an agronomic balance for phosphorus or potassium.

2. Enter information to calculate manure balances (**dairy**, Worksheets7 and 7.1: manure imports and exports, livestock/animal, manure storage system, and grazing information; **non-dairy**, Worksheet 7 only: manure imports and exports, livestock/animal).

- If manure types were split in Worksheet 4 according to their application method, group them together in Column C and sum the total weight of the manure to be applied (e.g. combine "liquid dairy-spring" and "liquid dairy-summer" into "liquid dairy").

3. Change nutrient application rates while evaluating crop removal balances (Worksheets 5 and 6).

- If possible, achieve an agronomic balance for all three nutrients by increasing fertilizer rates (Worksheet 5). If the agronomic P or K balance is negative, the field in question will be oversupplied with either phosphorus or potassium for optimal crop production. It is advisable to not apply any more manure to these fields.
- If manure must be applied, select the application rates based on the priority nutrient (see Chapter 3):
  - if K is the priority nutrient, the crop removal balance for potassium should be greater than or equal to zero (i.e. the total potassium applied should not exceed the expected crop potassium removal)
  - if P is the priority nutrient, the crop removal balance for phosphorus should be greater than or equal to zero.
  - if N is the priority nutrient, the agronomic balance for nitrogen should be greater than or equal to zero.
- If you choose nutrient application rates that exceed crop K or P removal balances, the best strategy is to exceed removal only in fields with the lowest risk of high soil K to the livestock or lowest risk of soil P transport to the environment.

Alternatively, if there are no negative agronomic balances, crop removal balances may still be negative. This indicates the planned application rate presents minimal risk in the short term and a build up of soil K or P (indicated by negative crop removal balances) that is not sustainable in the long term, after the soil test K or P reaches high or excess levels.

📖 **for detailed phosphorus and potassium management information, see Nutrient Management Factsheet Series #6: Phosphorus Management *and* #7: Potassium Management**

4. Recalculate the manure balances using the final manure application rates selected (Worksheet 7).

WORKSHEETS 8 AND 9: MANURE APPLICATION RATES AND TIMING FOR FIELD USE

After annual manure application rates are determined (as tankers or loads per hectare or acre, Worksheet 8), the next step is to determine the amount to be applied for each application during the growing season (Worksheets 9a, 9b).

Individual Application Amount

Crops follow a relatively predictable growth curve as illustrated for corn in **Figure 1** and grass in **Figure 2**. Crops should be fertilized with an amount of nutrient which is proportional to the amount of annual growth expected prior to the next harvest. Figures 1 and 2 show the percent of annual manure application that should occur at the various manure spreading opportunities.

Consider the following guidelines:

- a single manure application should not exceed 50 m^3/ha (5300 gallons/ac) for slurry or 50 tonnes/ha (22 tons/ac) of solid manure
- for liquid manures on annual crops, if crop nutrient requirements suggest a higher rate than 50 m^3/ha (5300 gallons/ac), consider a split application and incorporate the first application prior to the second application
- leave at least three weeks between applications - this reduces sealing of the soil surface and allows for the soil to recover

Application Timing

Figures 4.4 and 4.5 show the times of the year when manure applications as a fertilizer should be considered. The optimal times to apply manure are before the crop needs the nutrients and when crop growth will not restrict manure application.

The South Coastal Region

- **February and March***:* If the soil is not saturated and not subject to flooding or runoff during this time period, manure can be applied on perennial grassland or well-established cover crops. Use T-Sum 200 or T Sum 300 as a guide to determine timing of first fertilizer application.
- **April to August***:* Avoid spreading on wet soils which could compact or cause crop damage.
- **September and October***:* In general, manure application is suitable only on grasslands that are well drained and not subject to flooding or runoff. Winter cover crops must be well established before any manure application is contemplated on annually cropped land.
- **November to January***:* Application of manure is not recommended.

The Interior Region:

- **March to May***:* Manure fertilizer application should only be considered within fields with no history of runoff or flooding during this time period, and on soils that are not snow covered or frozen.
- **June to August***:* Avoid spreading on wet soils which could compact or cause crop damage.
- **September and October***:* Manure application to thawed ground only.
- **November to February***:* Application of fertilizer (particularly manures) is not recommended. If spreading is to occur, then spread only on fields with no history of runoff or flooding, and with soils that are not snow covered or frozen.

📖 **for more detailed guidelines on timing of manure application, EFP Reference Guide, Chapter 6**

In addition to crop and seasonal climate conditions, the farmer and manure applicator will also consider time of day and weather conditions that affect drift and odour (i.e. ideal to spread when it is cool and early morning, little wind, etc.)

There are times when manure application is not acceptable due to the risk of impacting the environment or little potential for nutrient utilization by the crop.

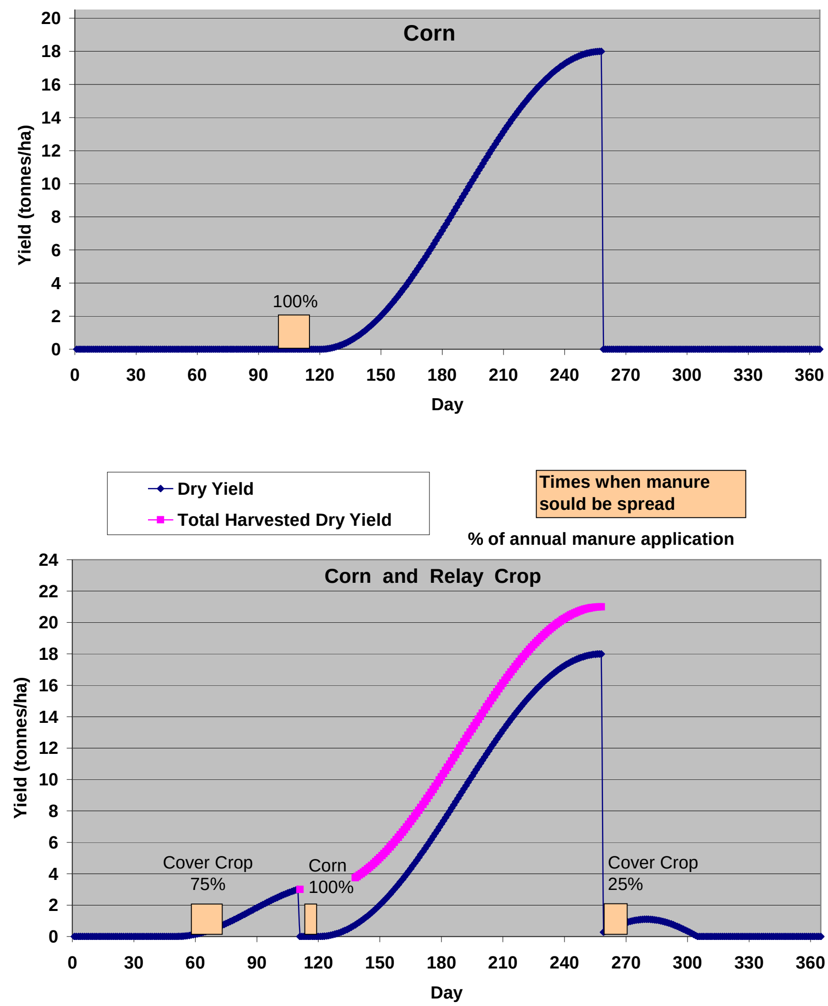

Figure 4.4: Typical Corn Growth Curves and Manure Spreading Opportunities with Approximate Percent of Annual Manure Application for:

a. corn typical for South Coastal and Okanagan/Thompson areas

b. corn planted with a relay crop typical for South Coastal areas

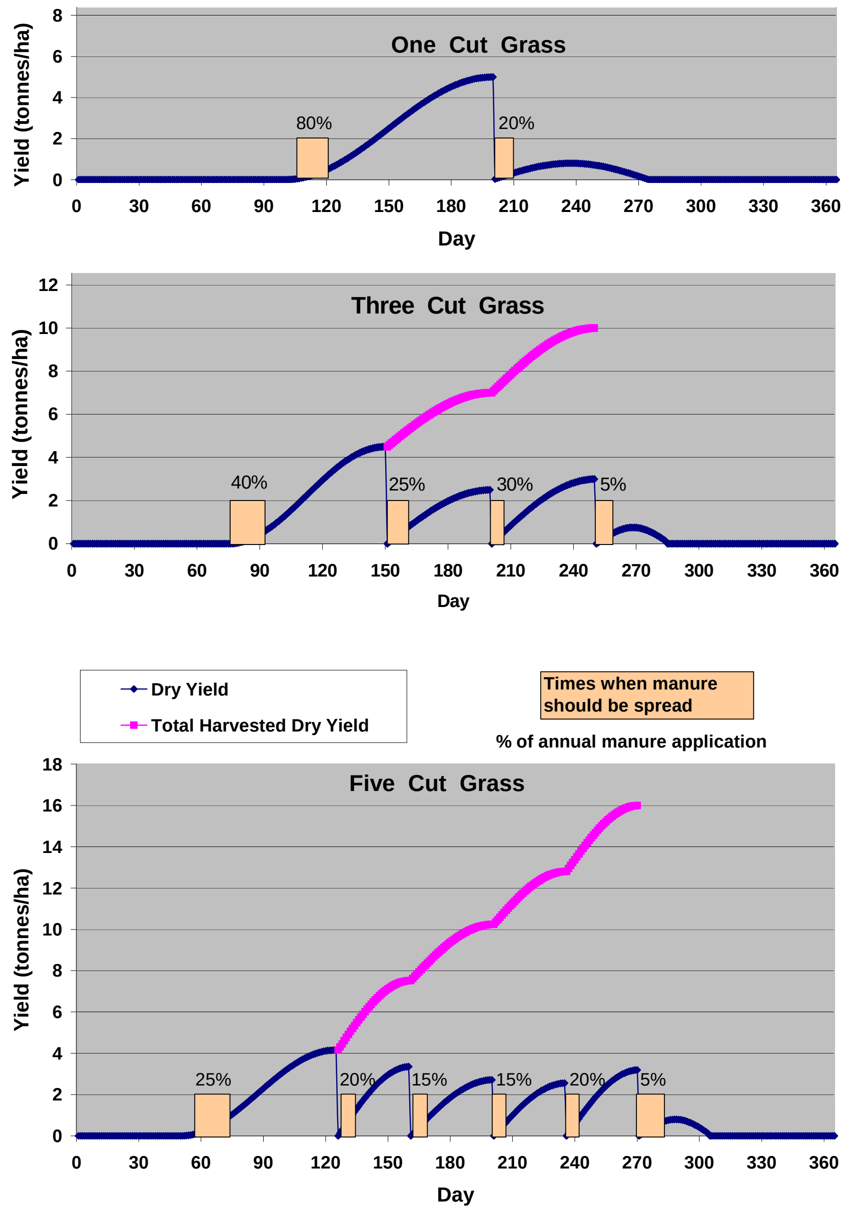

Figure 4.5: Typical Grass Growth Curves and Manure Spreading Opportunities with Approximate Percent of Annual Manure Application for:

a. One cut grass typical for dryland Interior areas

b. Three cut grass typical for dryland South Coastal areas

c. Five cut grass typical for South Coastal and irrigated Okanagan/Thompson areas

RECORD KEEPER

This is a worksheet for printing out field record sheets to record actual practices and compare them with planned practices (optional).

VEGETABLE NMP CALCULATOR

The Vegetable NMP Calculator will help meet the following objectives:

- determine crop nutrient recommendations
- estimate available nutrient supply from soil and manures
- determine appropriate amount of supplemental fertilizer to be applied, if required

The worksheet flowchart (Figure 4.6) gives an overview of how the worksheets of the Vegetable NMP Calculator link with each other. When the program is opened in Excel, the user completes the worksheets from left to right – beginning with the Soil Tests worksheet and ending with the Farm Summary worksheet as shown in the flowchart. Each worksheet is completed from top to bottom.

- Data specific to a field are shown on the same worksheet and fields are separated by different worksheets.

More detailed explanations about how the program works and the calculations in each worksheet are in the program itself and are not repeated here. Instead, this section provides support for those steps where the Planning Advisor needs to make decisions about what data to enter. These steps are marked in the flowchart by parallelograms and diamonds and are discussed below according to the worksheet. The outputs are marked in the flowchart as rectangles.

Note: The assumptions used in the tables in the Vegetable NMP Calculator are based on the same assumptions as in the Forage NMP Calculator.

"SOIL TESTS" WORKSHEET

Enter data from soil tests. Having good data from the laboratory analyses is crucial to producing reliable estimates of nutrient recommendations. Here are tips and questions to ensure you are entering good laboratory data:

- Check the data as soon as you get results. If confidence in the data is low, you may be able to have the laboratory reanalyze the sample(s) before the laboratory disposes of them. Alternatively, you may decide to take another set of samples for analysis if time permits.
- Are the data in the same units as those required in the program? Use book values and conversion factors in the program. Note whether phosphorus is given as P or P_2O_5 and whether it is K or K_2O.
- Do soil test P and K ratings make sense compared with previous results? Dramatic changes in these nutrients from one year to the next are unusual in typical cases, as are sudden departures from year-to-year trends in levels of these nutrients.
- If soil test values are reported as a range (e.g. "> 60 ppm"), ask for the soil sample to be reanalyzed and the result to be reported as an absolute value.

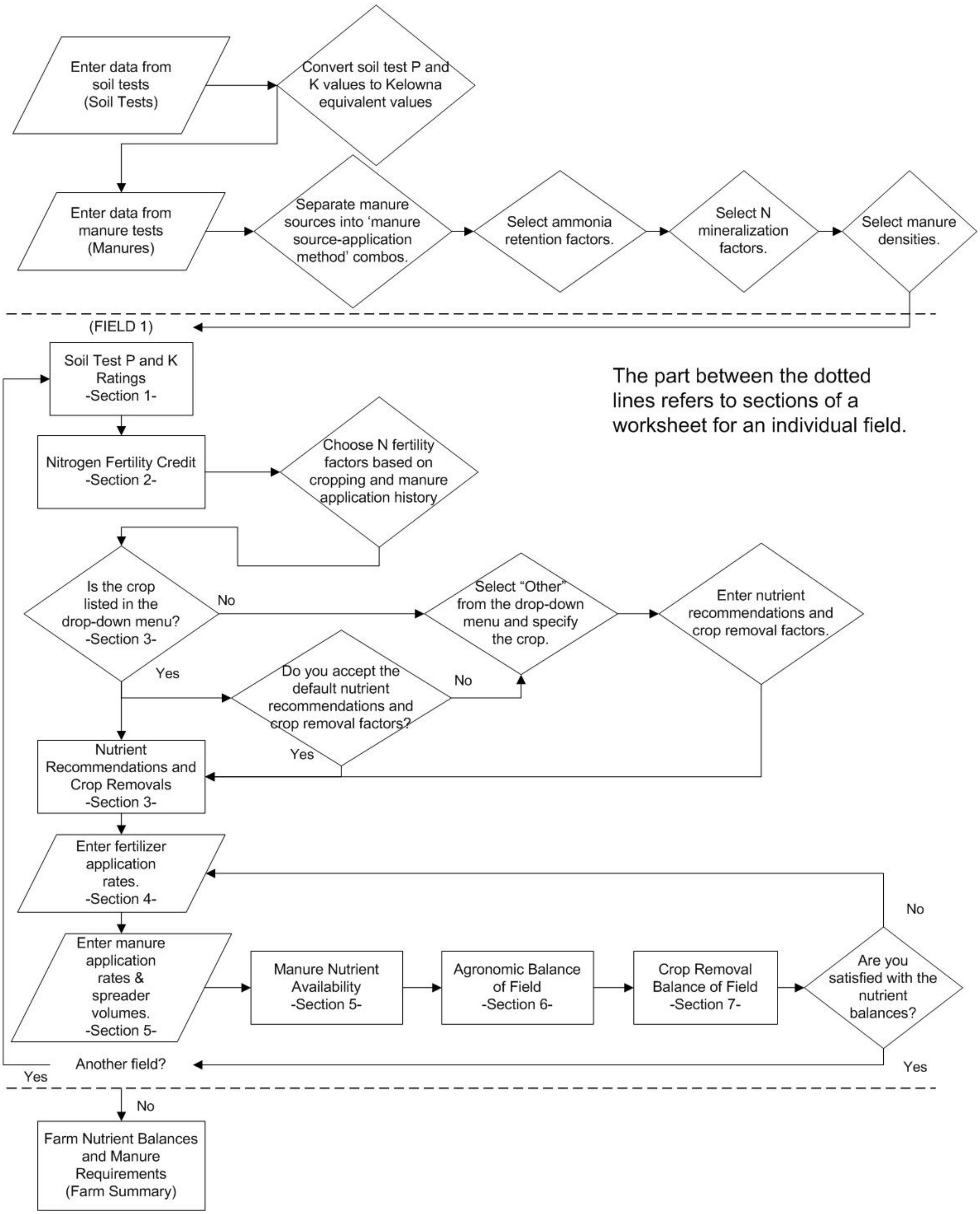

Figure 4.6 Flowchart overview of process for completing worksheets in Vegetable NMP Calculator

Convert soil test P and K values to Kelowna equivalent values.

- If the soil test P method used is bicarbonate (i.e. Olsen method), you will most likely choose the bicarbonate-**colorimetry** method for converting the value to the Kelowna method equivalent. This conversion has the least certainty of the conversions provided.
- Pick the proper method. Some laboratories are known to report soil P values using multiple methods.
- If there is no confidence in using the soil test results, consider using historical data if they are available and recent (i.e. collected in the previous three years) until samples can be retaken according to **Factsheet 2** for sampling guidelines. Keep notes about sampling protocols and environmental conditions around the time of sampling that may explain discrepancies between expected values and laboratory results.

"MANURES" WORKSHEET

Enter data from manure tests. As with soil tests, ensure you are entering reliable data to produce reliable results in the NMP Calculator.

- Ideally, the values are from samples taken just before the manure is applied in the spring. However, if the nutrient management plan is being done in the fall, a fall sample can be used until there are reliable values for spring samples.
- Compare the laboratory values for manures with book values. Although nutrient contents of these materials vary from farm to farm, they should be reasonably close to the book values provided in the program. If they are not and you have a reasonable explanation for the difference, be prepared to explain the difference.
- Are the data in the same units as those required in the program? Use book values and conversion factors in the program. Note whether phosphorus is given as P or P_2O_5 and whether it is K or K_2O.
- If there is no confidence in using the laboratory results, consider using historical data and book values if available until samples can be retaken according to **Factsheet 5** for sampling guidelines. Keep notes about sampling protocols and environmental conditions around the time of sampling that may explain discrepancies between expected values and laboratory results.

Separate manure sources into manure source-application method combinations. Because of the high variability in nitrogen losses under different manure spreading conditions, it is important to try and account for the most probable situations. In this worksheet, make a separate and well-described line entry where any of the following combinations of conditions may vary:

- ♦ manure type – poultry, beef, etc. (and liquid or solid)
- ♦ manure application method – time between application and incorporation if manure is incorporated into the soil

Select ammonia retention factors. This is directly related to the time between manure application and incorporation.

If liquid manure is used, see the “Select ammonia retention factors” section for the Forage NMP Calculator (p. 21) to customize the value you enter.

Select N mineralization factors. See Table 6 in the worksheet for help.

WORKSHEETS FOR INDIVIDUAL FIELDS

Section 2. Choose N fertility factors based on cropping and manure application history. This is one of the steps in the planning process with least certainty. The actual nitrogen credits from historical practices will vary with the practices as well as the conditions (e.g. soil moisture and temperature) that are more difficult to predict. The Planning Advisor has the flexibility to change nitrogen credits according to the following principles:

- If legumes (e.g. clover, vetch) are planted as part or all of a cover crop that is ploughed down before a vegetable crop, the N fertility credit can be increased up to 150 kg N/ha (130 lb N/ac).
- Non-leguminous cover crops that were ploughed down were given N fertility credit in the previous version of the NMP Calculator. Although these crops are useful in taking up residual nitrogen after a growing season, no N fertility credit is recommended for the following vegetable crop in the Veg NMP Calculator.
- The N released (mineralized) from organic nitrogen amendments in previous years depends on various factors including the source and rates. As a rule of thumb, the Planning Advisor can adjust the N fertility credit due to past poultry manure applications by assuming that 15% of the total N applied one year ago and 7% of the total N applied two years ago will become available in the current year – this assumes that the past rates are known or can be estimated.

Section 3. Select a crop from the drop-down list or specify your own crop. Depending on the soil test P and K levels for the specific field and the crop, this selection affects the P_2O_5 and K_2O recommendations as well as the values that determine crop N, P and K removal.

- If you think you need to override the default values provided for a listed crop, you can specify “Other” crop and type in the P_2O_5 and K_2O recommendations and factors yourself with a justification for these values in the written portion of the nutrient management plan.

Sections 4 to 7 include the following:

- Section 4. Enter fertilizer application rates.
- Section 5. Enter manure application rates and spreader volumes.
- Section 6. Agronomic balances of the field.
- Section 7. Crop removal balances of the field.

Deciding what data to enter into sections 4 to 7 is an iterative process that begins with entering tentative fertilizer and manure application rates. Then the Planning Advisor should revise these rates according to the following guidelines:

- Ideally, rates are selected that result in agronomic balances equal to zero for all three nutrients.

- If phosphorus is the priority nutrient for a field,

1. Try to avoid a negative agronomic P_2O_5 balance (indicating more available phosphorus is supplied than recommended for an optimal crop). As an interim guideline, the program warns the user when an agronomic balance is less than an insurance amount of -15 kg P_2O_5/ha. An orange-highlighted value indicates this warning.
2. If negative agronomic P balances cannot be avoided, try to avoid negative crop P removal balances (i.e. less than -70 kg P_2O_5/ha, crop removal balance). As an interim guideline, the program warns the user when a crop removal balance is less than an insurance amount of -70 kg P_2O_5/ha. An orange-highlighted value indicates this warning. Negative crop P removal balances indicate situations of phosphorus loading or accumulation, which is acceptable only at low to medium soil P levels.
3. If both the agronomic and crop removal balances for P_2O_5 are highlighted, decrease the planned nutrient application rates.

- If nitrogen is the priority nutrient for a field, then limit agronomic nitrogen balances to positive values or do not recommend any nitrogen applications in any form.

This process for individual fields is repeated for other fields (up to 16).

FARM SUMMARY

Among other things, this worksheet estimates the amount of manure required according to the planned manure application rates for each field and field sizes.

RECORD KEEPER

This is a worksheet for printing out field record sheets to record actual practices and compare them with planned practices (optional).

BERRY NMP CALCULATOR

The Berry NMP Calculator will help meet the following objectives:

- estimate available nutrient supply from soil and manures.
- show how plant vigour and post-harvest nitrate values are related for raspberries, using a mix of numbers and subjective rankings.
- suggest a reasonable range for crop nutrient recommendations for raspberries and blueberries.

Disclaimer: At the time of writing, the Berry NMP Calculator was meant to be primarily an educational tool that a trained Environmental Farm Plan Planning Advisor can work through with a berry farmer. It is not meant to replace the expertise of professionals in berry production or the experience of a berry farmer. Although the Berry NMP Calculator provides ranges for nutrient recommendations, it does not currently integrate factors that might influence actual crop requirements – factors such as soil pH, soil type, soil organic matter, tissue tests and crop variety.

USING THE WORKSHEETS

There are three worksheets to work through for raspberries and blueberries.

1. Manure Nitrogen.

Key learning outcome: understand the nitrogen value of current and previous manure applications.

i. Whether manure will be used or not, begin by entering the year for which nutrients will be applied.
ii. If manure will be used, or has been used in the past two years, enter the nitrogen data from the manure tests or use the suggested book values for the poultry manure type in the drop-down menu.
   - Currently, the manure type must be chosen from one of three poultry manure types that does not include composted manure or other amendments. Until these are added to future revisions of the NMP Calculator, use one of the three manure types for educational purposes if your manure/amendment is not shown.

iii. Enter the (approximate) manure application rates for each year manure was applied.

Example: If 7 spreader loads were used per hectare (i.e. just under 3 loads per acre), and each load had 2.5 yd^3 of manure, then the application rate would be 17.5 yd^3/ha (or 7 yd^3/ac).

Alternatively, estimate the manure application rate based on the appearance of 100 kg N/ha (total N) as broiler and layer manure in Figures 4.7 and 4.8. Because of the high nutrient concentration of poultry manure, this application rate results in a very thin layer of manure being applied, equivalent to less than 10 yd^3/ha (4 yd^3/ac) of broiler manure or 12 yd^3/ha (5 yd^3/ac) of layer manure.

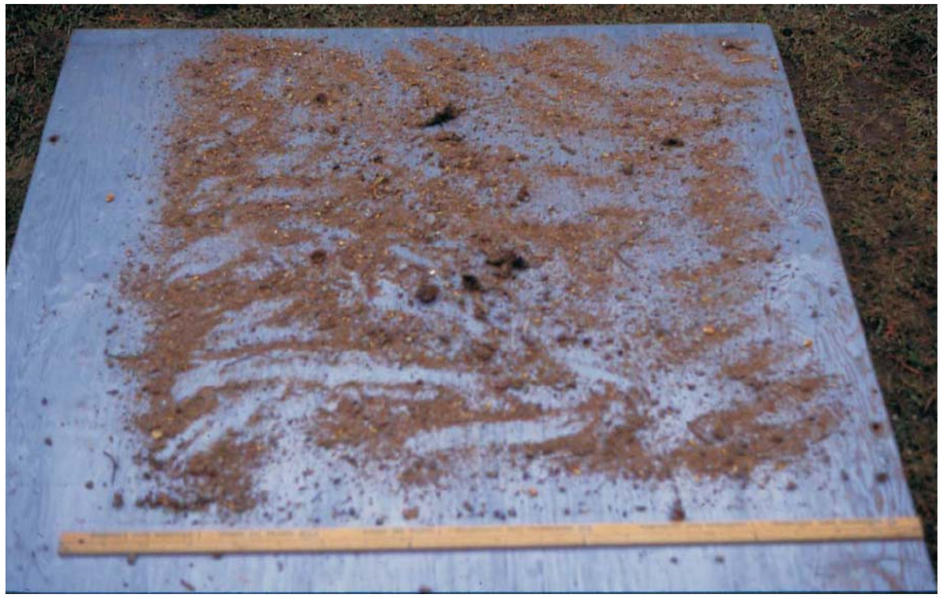

Figure 4.7. Broiler manure laid out on a 1 x 1 m board at a rate of 100 kg N/ha (90 lb N/acre). Photo courtesy of Dr. Bernie Zebarth (Agriculture and Agri-Food Canada).

Figure 4.8. Layer manure laid out on a 1 x 1 m board at a rate of 100 kg N/ha (90 lb N/acre). Photo courtesy of Dr. Bernie Zebarth (Agriculture and Agri-Food Canada).

2a. Fertilizer Nitrogen Recommendations (for Raspberries only).

Key learning outcomes:

- Understand that poor vigour in the primocanes during the fall indicates a low potential for the plant to take up nitrogen in the following year. Nitrogen application rates can be decreased; they should not be increased.
- Post-harvest nitrate values from late summer soil samples (0-30 cm) provide useful feedback that can be used to adjust future nitrogen application rates.

i. Select the plant vigour from the drop-down menu: weak, normal or excessive. The Planning Advisor and farmer should begin with the assessment that they believe to the most accurate description of the vigour of the primocanes. Later, they can change the value to understand what different 'vigour-PHNT' combinations might indicate.
ii. Enter the post-harvest nitrate test (PHNT) value. If no PHNT was taken, try entering different numbers to see how the program interprets various vigour-PHNT combinations.
iii. Enter your crop nitrogen (uptake) requirement. This represents the potential maximum nitrogen that the plant can take up from all nutrient sources. Do not exceed 70 kg N/ha.
iv. Select the cover crop vigour from the drop-down menu.
v. Enter the cover crop N credit, selecting a value in the recommended range of N credits.
vi. Enter the fertilizer N rate according to the instructions in the worksheet.

2b. Fertilizer Nitrogen Recommendations (for Blueberries only).

At this time, the Berry NMP Calculator simply summarizes the nitrogen recommendations from the 2009/10 Berry Production Guide. The recommendations do not depend on soil N testing.

3. Manure Phosphorus and Potassium.

Key learning outcomes:

- Understand the P and K value of manure.
- Understand the recommended amounts of P and K for berry crops according to soil test values.

i. Worksheet 3A: If manure will be used, or has been used in the past two years, enter the phosphorus and potassium data from the manure tests or use the suggested book values for the poultry manure type in the drop-down menu.
- Currently, the manure type must be chosen from one of three poultry manure types that does not include composted manure or other amendments. Until these are added to future revisions of the NMP Calculator, use one of the three manure types for educational purposes if your manure/amendment is not shown.

ii. Worksheet 3B. Enter the soil test phosphorus data from the laboratory report, specifying the laboratory method.
iii. Worksheet 3B. Enter the P recommendation, selecting a number in the suggested range.
iv. Worksheet 3B. Note the P fertilizer recommendation. A negative value indicates that available P from the manure and fertilizer exceeds the recommended amount according to the soil test value.
v. Worksheet 3C. Repeat steps ii to iv, replacing P with K.

Manure P availablity is assumed to be 50%. This is likely an underestimate: more than 50% of the total manure P is probably available in the year of application at high soil test P levels.

Other fields

Optionally, restart the process at the **Manures** worksheet for other fields (recommended if other fields are managed differently).

REFERENCES

Assumptions underlying the NMP Calculators are based on the sources cited below. In cases where confidence in the information was high (i.e. assumed to be reliable, relevant and recent), assumptions follow directly from results and recommendations in these sources. In other cases, the assumptions were based on a mix of best information, assumptions in the previous NMP Calculator from 2005 and the judgment of the developers of the NMP Calculators.

General	
N fertility factor: nitrogen credit due to previous forage stand	Pennsylvania State University. 2008. Penn State Agronomy Guide 2009-10. Table 1.2-7. Residual nitrogen contribution from legumes. Available at http://agguide.agronomy.psu.edu/cm/sec2/table1-2-7.cfm Ontario Ministry of Agriculture, Food and Rural Affairs. 2009. Corn: fertility management. Available at http://www.omafra.gov.on.ca/english/crops/pub811/1fertility.htm#tabled
N fertility factor: nitrogen credit due to leguminous cover crop	Burket, J., Sandeno, J., Hemphill, D., and Dick, R. 2003. Cover crop nitrogen for summer vegetable crops. Oregon State University Extension Service. EM-8803-E. Available at http://extension.oregonstate.edu/catalog/pdf/em/em8803-e.pdf Ontario Ministry of Agriculture, Food and Rural Affairs. 2004. Nutrient management in growing crops (Info Sheet). http://www.omafra.gov.on.ca/english/environment/efp/infosheet_16.htm Garrett, A. 2009. Improving Nitrogen Management with Cover Crops in Organic Broccoli Production. Oregon State University. MSc Thesis. http://ir.library.oregonstate.edu/jspui/bitstream/1957/12109/1/FINAL%20MANUSCRIPT-PDF.pdf
N fertility factor: previous manure applications	Sullivan, D. 2008. Estimating plant-available nitrogen from manure. Oregon State University Extension Service. EM-8594-E. Available at http://extension.oregonstate.edu/catalog/pdf/em/em8954-e.pdf Department for Environment, Food and Rural Affairs. 2010. Fertiliser Manual (RB209), 8th edition. Available at http://www.defra.gov.uk/foodfarm/landmanage/land-soil/nutrient/documents/rb209-rev-100609.pdf

Soil test ratings for phosphorus and potassium (for forage crops and vegetables)	Gough, N.A. 1991. (Republished in 1996.) Soil and plant tissue testing methods and interpretations of their results for British Columbia agricultural soil. Final draft report. BC Ministry of Agriculture and Food. Available at http://www.agf.gov.bc.ca/resmgmt/NutrientMgmt
Conversion factors for soil test phosphorus and potassium methods	Kowalenko, C.G. 2010. Relationships between extraction methods for Soil Nutrient Testing. Report for BC Ministry of Agriculture and Lands. Available at http://www.agf.gov.bc.ca/resmgmt/EnviroFarmPlanning/Relationships_Between_Extraction_Methods.pdf The proposed relationship between the Kelowna method and bicarbonate method for soil test phosphorus is based on, • van Lierop. W. 1988. Determination of available phosphorus in acid and calcareous soils with the Kelowna multiple-element extractant. Soil Science 148: 284-291. • Ige, D.V., Akinremi, O.O., Flaten, D., and Kashem, M.A. 2006. Comparison of soil test phosphorus methods in neutral to calcareous Manitoba soils. Canadian Journal of Soil Science 86: 691-699.
Nitrogen mineralization factors of manures (in year of application)	Sullivan, D. 2008. Estimating plant-available nitrogen from manure. Oregon State University Extension Service. EM-8594-E. Available at http://extension.oregonstate.edu/catalog/pdf/em/em8954-e.pdf Temple, W. Research Associate, University of British Columbia. Personal communication. September 13, 2010. Pennsylvania State University. 2008. Penn State Agronomy Guide 2009-10. Table 1.2-15. Factors for calculating manure nitrogen availability based on time of application, incorporation, field history, and manure analysis with ammonium and organic N fractions. Available at http://agguide.agronomy.psu.edu/cm/sec2/table1-2-7.cfm Alberta Agriculture and Rural Development. 2008. Nutrient management planning guide: Chapter 4.3 Manure test interpretation. Available at http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/epw11920/$FILE/4-3.pdf

Manure phosphorus and potassium availability	Sneller, E.G. and Laboski, C.A.M. 2009. Phosphorus source effects on corn utilization and changes in soil test. Agronomy Journal 101: 663-670. Hayden, V.R., Ketterings, Q.M., and Kahabka, J.E. 2007. Factors affecting change in soil test phosphorus following manure and fertilizer application. Soil Science Society of America Journal 71: 1225-1232. Alberta Agriculture and Rural Development. 2008. Nutrient management planning guide: Chapter 4.3 Manure test interpretation. Available at http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/epw11920/$FILE/4-3.pdf Iowa State University Extension. 2008. Using manure nutrients for crop production. PMR-1003. Available at http://www.extension.iastate.edu/Publications/PMR1003.pdf Sullivan, D. Extension soil scientist, Oregon State University. Personal communication (email). September 16, 2010.
Nutrient contents of animal manures, book values	Liquid Dairy Manure – 2005 manure pit survey by B. Swift, as published in “Nutrient Management Field Record Book” by BC Milk Producers Association. Poultry – BC Sustainable Poultry Farming Group. 1994. Fact Sheet available at http://www.sustainablepoultry.com/NuFactSheet/factsheetnutrientcontent.htm Beef and Solid Dairy – North Okanagan Soil Conservation Group (1994); Swine – Hog Producers’ Sustainable Farming Group. (ca. 1993), as cited in Soil Management Handbook for the Okanagan and Similkameen Valleys (1994) by BC Ministry of Agriculture, Food and Fisheries, available at http://www.agf.gov.bc.ca/resmgmt/publist/600Series/610000-6_Soil_Mgmt_Handbook_Okanagan.pdf
Ammonia retention factors	Ammonia Loss Calculator developed by S. Bittman et al. (Agriculture and Agri-Food Canada). Available at http://www.farmwest.com/index.cfm?method=climateammonia.showgraph Sullivan, D. 2008. Estimating plant-available nitrogen from manure. Oregon State University Extension Service. EM-8594-E. Available at http://extension.oregonstate.edu/catalog/pdf/em/em8954-e.pdf Pennsylvania State University. 2008. Penn State Agronomy Guide 2009-10. Table 1.2-15. Factors for calculating manure nitrogen availability based on time of application, incorporation, field history, and manure analysis with ammonium and organic N fractions. Available at http://agguide.agronomy.psu.edu/cm/pdf/table1-2-15.pdf
Solid manure densities, book values	Poultry manure densities – BC Sustainable Poultry Farming Group. 1994. Fact Sheet available at http://www.sustainablepoultry.com/NuFactSheet/factsheetnutrientcontent.htm

Forage NMP Calculator	
Nutrient contents of forage crops, book values, i.e. protein contents and crop phosphorus and potassium factors	Downing, T., Sullivan, D., Hart, J. and Gamroth, M. 2007. Manure application rates for forage production. Oregon State University Extension Service. EM-8585-E. Available at http://extension.oregonstate.edu/catalog/pdf/em/em8585-e.pdf "SCS Agricultural Handbook by Grusenmeyer" as cited in Peterson, B. 1995. Manure Management Guidelines for Western Washington, Appendix F. WSU Cooperative Extension – Whatcom County. Available at http://whatcom.wsu.edu/ag/nutrient/Appendix_F.PDF
Annual Manure Production for Dairy Cattle	Rick Van Kleeck. 2004. Dairy Manure Storage Sizing and Costing Tool (Excel spreadsheet). BC Ministry of Agriculture, Food and Fisheries. Rick Van Kleeck. Investment Agriculture Foundation of British Columbia. Personal communication. September 16, 2010. • Daily manure production values - "Canadian Farm Building Code 1977." 1977. Table XXVII, p. 80. Associate Committee on the National Building Code, National Research Council of Canada. • Rainfall values - Environment Canada. Canadian Climate Normals or Averages 1971-2000. Available at http://www.climate.weatheroffice.gc.ca/climate_normals/index_e.html • Lake evaporation values - Environment Canada. 1984. Canadian Climate Normals 1951-1980. "Volume 9: Soil temperature, lake evaporation, days with..." • Separated manure solids density – Gangwer, M. "Mechanical manure separation." Oregon State University Extension Service.

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Vegetable NMP Calculator	
Crop N, P and K factors, book values	Values are a weighted average of values from the following sources: US Department of Agriculture. Crop Nutrient Tool. Available at http://plants.usda.gov/npk/AboutNutrient Values from this source were given 50% weighting. The other 50% was the average of values from the sources below. Ontario Ministry of Agriculture, Food and Rural Affairs. 2009. NMAN2.1. Available at http://www.omafra.gov.on.ca/english/nm/nman/software.htm Department for Environment, Food and Rural Affairs. 2010. http://www.defra.gov.uk/foodfarm/landmanage/land-soil/nutrient/nmu01.htm Schroeder, K. Nutrient removal rates and replacement costs for vegetable crops. University of Wisconsin-Extension. PowerPoint presentation. Available at http://waushara.uwex.edu/ag/documents/NutrientRemovalandReplacementCostsforVegetablesKS3-11-09.pdf Warncke, D.D., Christenson, D.R., Jacobs, L.W., Vitosh, M.L. and Zandstra, B.H. 1992. Fertilizer recommendations for vegetable crops in Michigan. Michigan State University - Cooperation Extension Service. E-550B. Available at http://www.emdc.msue.msu.edu/Bulletin/PDF/E0550B.pdf
Nitrogen uptake requirements	BC Ministry of Agriculture and Lands. 2010. 2010-2011 Vegetable Production Guide - Beneficial Management Practices for Commercial Growers in British Columbia. Reid, K. 2010. Fertilizer Recommendation Tables – 2009 Revision. Ontario Ministry of Agriculture, Food and Rural Affairs. Available at http://www.omafra.gov.on.ca/english/crops/facts/fert-rec-tables-9.htm
Berry NMP Calculator	
Soil test P and K interpretations	Charles Mouritzen. Southwest Crop Consulting. Personal communication (email). March 31, 2009. Kowalenko, C.G. 2010. Relationships between extraction methods for Soil Nutrient Testing. Report for BC Ministry of Agriculture and Lands. Available at http://www.agf.gov.bc.ca/resmgmt/EnviroFarmPlanning/Relationships_Between_Extraction_Methods.pdf

N recommendations for raspberries, post-harvest nitrate test for raspberries	Sweeney, M. BC Ministry of Agriculture and Lands. Personal communication. 2009. Hart, J., Strik, B., Rempel, H. 2006. Caneberries Nutrient Management Guide. Oregon State University Extension Service. EM-8903-E. Available at http://extension.oregonstate.edu/catalog/html/em/em8903-e/ Zebarth, B. Agriculture and Agri-Food Canada. Personal communication. August 4, 2010.
N mineralization factors of poultry manure (in year two and three)	Sullivan, D. 2008. Estimating plant-available nitrogen from manure. Oregon State University Extension Service. EM-8594-E. Available at http://extension.oregonstate.edu/catalog/pdf/em/em8954-e.pdf
N recommendations for blueberries	BC Ministry of Agriculture and Lands. 2009. 2009/2010 Berry Production Guide - Beneficial Management Practices for Berry Growers in British Columbia.

5 ASSEMBLING THE NUTRIENT MANAGEMENT PLAN

This chapter contains information on assembling the Nutrient Management Plan. The value of a plan depends largely on how the farmer uses it.

Nutrient Management Planning is not a one-time activity but an ongoing process. To make the plan practical, it must be kept in a form that will make it easy for the farmer to find the information they are looking for and also easy to record new information about manure applications, crop harvests, etc.

There are various ways to organize the information created using the NMP Calculators. One way would be to print out the worksheets once the planner is satisifed that the results meets the objectives. The 2010 updates to the NMP Calculator include a suite of spreadsheets that have been customized for specific crop groupings. The outputs of the various NMP Calculators are different so there is no one standard way of organizing your information. It is most important to organize it in a logical manner.

In addition to the worksheets, the Nutrient Management Plan should consist of written sections that provide context for the plan including the planning advisor's conclusions and recommendations that result from using the NMP Calculator software.

BINDER CHECKLIST

Here is a checklist you can use to ensure that the plan is complete:

A. Title Page

The title page identifies the farm name, contact information, and the date the plan was prepared. A signature on this page or on a separate page is strictly optional and can be used to show that the planning advisor has signed off on the Nutrient Management Plan.

B. Summary

This section contains a brief written summary of the Nutrient Management Plan. The key information includes:

- Goals and objectives of the Nutrient Management Plan
- A general description of the farm including land base and number of livestock
- Description of the manure handling and storage system
- Description of the manure being produced, imported or exported
- Summary of soil sampling procedures and test results
- Discussion of the farm's nutrient application schedule
- Conclusions and recommendations

C. Maps and Diagrams

This section should contain a farmstead map and a field map. The names given each field on the map should match the names used throughout the NMP Calculator worksheets and plan.

These maps will have been prepared during the Data Collection phase (Chapter 2). They may be prepared while developing an Environmental Farm Plan and can be copied to the Nutrient Management Plan. For Nutrient Management Planning, these maps are most useful if they accomplish the following:

- Identify soil sampling units, taking into account variability and usual areas due to differences in cropping, manure and fertilizer application history, topography, soil type or texture (drainage), etc.
- Identify potentially sensitive areas including watercourses, wells, etc. Field sizes (spreadable areas) and land management practices recommended in the plan should reflect this information.

📖 **Nutrient Management Factsheet Series #2: Soil Sampling**

D. Farm Nutrient Balance Summary

This section contains the summary of nutrient balances for all fields on the farm.

- For the Forage NMP Calculator, print or refer to Worksheet 7. This worksheet summarizes the manure balances for each manure type.
- For the Vegetable NMP Calculator, print or refer to the "Farm Summary" worksheet. This worksheet summarizes the agronomic and crop removal balances as well as manure balances for the whole farm.
- For the Berry NMP Calculator, no worksheet currently provides an estimate for the whole farm. The planner can make a general statement about agronomic balances for indivdiual fields or the farm as a whole (optional).

E. Conclusions and Recommendations

Throughout the entire Nutrient Management Planning process, one of the roles of the planning advisor is to identify areas where practices can be improved to increase nutrient use efficiency and/or reduce risk to the environment. In addition to developing and fine-tuning the nutrient application schedule, written recommendations should address the following:

▶ If the calculations determine that the farm is generating more manure nutrients than can be utilized sustainably, the plan should include a strategy for dealing with nutrient surpluses. Options include altering feed rations to reduce nutrient levels in manure, use of cover crops to increase annual crop production, transporting manure off the farm, etc. Recommendations should consider the priority nutrient for each field, and general suggestions are provided in factsheets included in this guide.

📖 **Nutrient Management Factsheet Series #6: Phosphorus Considerations**

📖 **Nutrient Management Factsheet Series #7: Potassium Considerations**

- ▶ If the manure application equipment that is being used is not suitable to meet the application objectives of uniformity and accuracy of placement and rate, recommendations should be made for calibrating and adjusting equipment or if necessary, using more suitable equipment.
- ▶ If current manure application practices pose an elevated risk of causing pollution to watercourses or groundwater, the plan should include recommendations to reduce this risk. This may involve increased use of cover crops, increased use of buffers in sensitive areas, or adjustments to timing of application.
- ▶ If current practices present an elevated risk of soil compaction or erosion, the plan should include recommendations to reduce this risk (e.g. avoiding very wet conditions, limiting traffic to specific areas, lower tire pressure, etc.)

The Nutrient Management Plan should complement and enhance the Environmental Farm Plan. When the Nutrient Management Plan is completed and implemented, the process should ensure that any questions in the Environmental Farm Plan Workbook related to nutrient management will be answered with a "Yes" or "Not Applicable."

F. Individual Field Summaries

This section contains worksheets that give field-specific information.

- For the Forage NMP Calculator, print or refer to Worksheets 5 and 6. These worksheets summarize the agronomic and crop removal balances for each field
- For the Vegetable NMP Calculator, print or refer to the individual field worksheets. Sections 6 and 7 of each worksheet summarize agronomic and crop removal balances, respectively.
- For the Berry NMP Calculator, the planning advisor can print or refer to worksheets 2 and 3 for raspberries (or only worksheet 3 for blueberries) for one or more fields. These worksheets provide recommendations based on the agronomic balance concept only.

See Chapter 3: Nutrient Optimization for more information about the concept of agronomic and crop removal nutrient balances.

G. Laboratory Reports

- Soil test results
- Manure test results
- Forage quality (or crop tissue) test results

In addition to the above lab reports, the planner should attach a summary of sampling protocols if they differed or expanded upon the guidelines in the sampling factsheets.

📖 **Nutrient Management Factsheet Series #2: Soil Sampling**

📖 **Nutrient Management Factsheet Series #4: Forage Crop Sampling**

📖 **Nutrient Management Factsheet Series #5: Manure Sampling**

MULTI-YEAR DATA ORGANIZATION

Ideally, a Nutrient Management Plan should be revisited each year and new reports should be generated to reflect changes in the Nutrient Management Planning strategy. The farmer can choose whether they want to start a new binder each year or add data from multiple years into the same binder.

For subsequent years, the same process for assembling a Nutrient Management Plan should be repeated. If using a new binder each year, the information in the binder should be inserted in the same order each year. It is recommended that a new binder be started every five years or more frequently.

6 RECORD KEEPING AND MONITORING

The first time that a Nutrient Management Plan is done, the quality of the plan may be less than ideal because many of the calculations are based on assumptions that are not necessarily backed up with solid information. However, as the farmer begins a process of keeping thorough organized records on nutrient management practices, the plan can be adjusted each year based on these records. Over time, the quality of the plan will improve substantially.

RECORDS THAT SHOULD BE KEPT

Chapter 5 outlined a process for setting up a binder that contains the Nutrient Management Plan and all related records including manure tests, soil tests, and forage tests.

The record-keeping component of the plan is a systematic way of recording the nutrient management practices that actually occurred.

The most important data to record includes:

- Crop grown
- Date, rate and method of all manure applications
- Date, rate and method of all chemical fertilizer applications including formulations
- Harvest (and planting/seeding) date
- Yield
- Crop quality information (or vigour assessment for berries)

If using the Forage or Vegetable NMP Calculators, the worksheet, "Record Keeper" can be used to generate forms that can help the producer organize records and compare actual activities with the planned activities at the end of the year.

Additional comments that can be helpful include statements about weather conditions (before and after nutrient applications) and the performance and uniformity of manure application equipment.

MONITORING

Once a Nutrient Management Plan is developed, there are a number of tests and suggested practices that can be utilized to ensure that the plan is working well. In some cases, the tests will also indicate a need to change values in the plan. The tests are indicated below and discussed briefly in the soil sampling factsheet.

Nutrient Management Factsheet Series #2: Soil Sampling

Pre-Sidedress Nitrate Test

The Pre-Sidedress Nitrate Test (PSNT) has been developed primarily for corn producers who apply nitrogen fertilizer to the crop just prior to the corn going into the rapid growth stage. The test is used to evaluate if additional nitrogen is required and if so, how much.

To conduct the test, soil samples are collected mid-way between the corn rows when the corn is at about the 6 leaf stage (usually mid-June) and submitted to a laboratory for analysis.

Research has shown that if soil test nitrate values are above 30 parts per million (ppm), there will not normally be an economically viable crop response to a sidedress application of fertilizer nitrogen. Table 3, below, provides suggested application rates if the PSNT value is below 30.

Table 6.1: Fertilizer Nitrogen Recommendations Based on the Pre-Sidedress Nitrate Test

PSNT test value (ppm, 30 cm depth)	Fertilizer N recommendation (kg N ha^{-1})
PSNT > 30	0
30 ≥ PSNT > 26	25
26 ≥ PSNT > 21	50
21 ≥ PSNT > 18	75
18 ≥ PSNT > 14	100
14 ≥ PSNT	125

**based on Zebarth, B.J. etal Reducing Risk of Groundwater Contamination Through Development of a Nitrogen Test for Silage Corn in South Coastal British Columbia. Final report for Project GP#3102, Agriculture & Agri-Food Canada 1999*

Post-Harvest Soil Nitrate Test

Note this is the main nitrogen test that has been developed for Nutrient Management Planning for raspberries. Interpretations for results are provided in the Berry NMP Calculator and they depend on a combination of the soil test and visual assessment of the plant vigour in the late summer.

The post-harvest nitrate test measures the quantity of plant available nitrogen present in the nitrate form in the surface 30 cm (one foot) of soil, assuming that nitrogen has not already been mostly leached below the 30 cm depth by rainfall or irrigation.

Whereas spring soil samples are taken to help predict how much fertilizer is needed for the upcoming season, fall (or late summer) sampling gives feedback about the accuracy of the predicted nitrogen supply relative to crop needs. If the crop yielded as expected and the soil level of nitrate is low in fall after crop growth has stopped, the amount of nitrogen applied in manure and fertilizer was appropriate for the crop grown (since the crop was able to use almost all of the applied nitrogen, leaving little to be leached). If the soil level of nitrate is high after crop growth has stopped and conditions were optimal for crop growth, the crop was not able to use all of the plant-available nitrogen released in the soil, and manure and/or fertilizer application rates should be reduced if the same crop will be grown next year.

In Coastal BC, most residual soil nitrate-nitrogen is expected to be lost from the soil through leaching over the winter and will eventually find its way to groundwater. In the Interior of BC, this is not the case: residual nitrate-nitrogen will be mostly available for crop growth next spring and should be considered when determining the nitrogen requirement for next year's crop.

Collecting samples: Fall sampling for soil nitrate level should occur after crop growth has stopped in fall (mid August to late October depending on crop) but before heavy fall rains begin. Once significant rainfall begins in late fall, nitrate will begin to move down in the soil profile beyond the sampling depth, and will move eventually to groundwater. Collect a composite sample from each field to a sampling depth of 30 cm.

If there is concern that some nitrate may have moved below this depth, sample an additional 30 cm. Make two separate composite samples – the 0 to 30 cm and the 30 to 60 cm depth samples. Keep the samples cool and send to the laboratory immediately to minimize changes in nitrate content of the soil sample. Conversely, if stones or rocks prevent samples from being taken at the ideal depth, note the actual sample depth to convert measurements to a volume (i.e. kg NO_3-N/ha) basis for comparison with the interpretations described below, using the guidelines in the soil sampling factsheet of this publication.

Interpreting the lab soil nitrate-nitrogen analysis: Lab results are usually expressed as "parts per million" nitrate-nitrogen (ppm or mg/kg NO_3-N). Convert ppm nitrate-nitrogen to kg per hectare by multiplying ppm by 3 (ppm x 3 = kg nitrate-nitrogen /ha). This assumes a soil bulk density of 1000 kg/m^3 and a sampling depth of 30 cm.

If the soil nitrate-nitrogen concentration is less than 20 ppm (60 kg NO_3-N/ha) for silage corn or less than 15 ppm (45 kg NO_3-N/ha) for perennial grasses, it is recommended to continue with present nitrogen management practices. If levels are above these thresholds, actions should be taken in the following year to reduce nitrogen excesses (i.e. reduce N application rate).

More detailed information on conducting and interpreting the post-harvest nitrate test is provided in the following publication.

- **Post-harvest Soil Nitrate Testing for Manured Cropping Systems West of the Cascades:** available on the Oregon State University extension website at http://extension.oregonstate.edu/catalog

Long-term Soil Quality Monitoring

Once every three to five years it is useful to do a complete nutrient, pH and metals scan on your soil samples as a way for you to monitor the long-term soil quality of your fields.

The Nutrient Management Planning worksheets look at only nitrogen, phosphorus and potassium levels in soil, look indirectly at soil pH and do not consider the secondary nutrients, micro nutrients, metals or other soil parameters that can change in your soil as the result of on-going manure and fertilizer applications and cropping practices. Understand that the levels and relative proportions of these 'other' nutrients affect soil fertility and crop production.

Have the additional analyses done on the same samples that you submit for nutrient management (0 to 15 cm depth). If metals will be analyzed on the samples, ensure that the sampling equipment is clean and rust-free, and that you wear rubber gloves. Request an analysis of the secondary nutrients calcium, magnesium, sodium and sulfur as well as micronutrients and metals, particularly copper and zinc.

Most agricultural laboratories have a standard nutrient and micronutrient/metals package that will give you the required background information to monitor soil quality. Lab analyses can be interpreted by a qualified agrologist or by a Ministry of Agriculture and Lands soils specialist. Reports should be kept on file, and be used to compare with on-going sampling results to pick out any significant changes in soil concentrations of metals or nutrients.

NUTRIENT MANAGEMENT FACTSHEETS

Nutrient Testing Laboratories

Nutrient Management Factsheet – No. 1 in Series

September 2010 – Order Reference No. 631-500-8

The following is a list of laboratories known to provide agricultural testing services for farmers in British Columbia, in particular for nutrient management. It is not an endorsement of any laboratory. For each laboratory, the types of analyses offered are listed by the following code:

- S = basic soil fertility
- C = crop or tissue nutrients
- M = manure or compost nutrients
- W = water quality

Note that laboratories may offer additional services not listed in this factsheet. If other services are required, contact the laboratories directly.

For the purposes of developing a Nutrient Management Plan for the Canada-BC Environmental Farm Plan program, only the basic soil fertility, crop nutrient, and manure nutrient analyses are used. Fertilizer recommendations on soil test reports are not used.

Locations in British Columbia

Agrichem Analytical
409 Stewart Rd, Saltspring Island BC V8K 1Y6
Phone/Fax: (250) 538-1712
Email: info@agrichem.ca Web: www.agrichem.ca

- Services offered: S, C, M, W

Exova (formerly Bodycote/Norwest)
#104, 19575 - 55A Avenue, Surrey, BC V3S 8P8
Phone: (604) 514-3322 Fax: (604) 514-3323
Toll free: (800) 889-1433
Web: www.exova.com

- Services offered: S*, C, M*, W

*Soil and manure analyses are done at another location

- Provides recommendations on soil test reports

Maxxam Analytics (formerly Cantest Ltd.)
4606 Canada Way, Burnaby BC V5G 1K5
Phone: 604-734-7276 Toll-free: 1 (800) 665-8566
Email : info@maxxamanalytics.com
Web: www.maxxam.ca

- Services offered: S*, M*, W

*Soil analyses are done by another laboratory

MB Laboratories Ltd.
By Courier: 4 - 2062 West Henry Ave, Sidney BC V8L 5Y1
By Mail: PO Box 2103, Sidney BC V8L 3S6
Phone: (250) 656-1334 Fax: (250) 656-0443
Email: mblabs@pacificcoast.net
Web: www.mblabs.com

- Services offered: S, C, M, W
- Provides recommendations on soil test reports

Pacific Soil Analysis Inc.
5 – 11720 Voyageur Way, Richmond BC V6X 3G9
Phone: (604) 273-8226 Fax: (604) 273-8082
Email: cedora19@telus.net

- Services offered: S, M

Plant Science Lab (affiliated with TerraLink Horticulture Inc.)
464 Riverside Road, Abbotsford, BC V2S 7M1
Phone: (604) 864-9044 Fax: (604) 864-8418
Toll Free: (800) 661-4559
Email: sales@terralink-horticulture.com

- Services offered: S, C, M*, W

*manure analyses are done at another laboratory

Canada
Growing Forward
A federal-provincial-territorial initiative
British Columbia
The Best Place on Earth

Some Locations Outside British Columbia

A & L Canada Laboratories Inc.
2136 Jetstream Road, London ON N5V 3P5
Phone: (519) 457-2575 Fax: (519) 457-2664
Web: www.alcanada.com

- Services offered: S, C, M, W
- Provides recommendations on soil test reports

ALS Laboratory Group
819 58 St. East, Saskatoon SK S7K 6X5
Phone: (306) 668-8370 Fax: (306) 668-8383
Toll free: (800) 667-7645
Web: www.alsglobal.com

- Services offered: S, C, M, W
- Provides recommendations on soil test reports

Brookside Laboratories Inc.
308 South Main St., New Knoxville OH 45871
Phone: (419) 753-2448 Fax: (419) 753-2949
Email: lbaker@blinc.com
Web: www.blinc.com

- Services offered: S, C, W

Soil Foodweb Canada Ltd.
285 Service Rd, Box 420 Vulcan, AB T0L 2B0
Phone: (403) 485-6981 Fax: (403) 485-6410
Email: info@soilfoodweb.ca
Web: www.soilfoodweb.ca

- Services offered: S, C

Know Your Soil Test Methods

Different laboratories use different methods, and soil test values for a soil sample can vary from one laboratory method to another. Soil nitrogen methods are an exception; the choice of the laboratory method should have a small effect on soil test values.

In conventional soil fertility testing, a method involves several factors. A main factor is the **extractant** (the chemical solution added to a given soil to remove what should reflect the 'available' portion of a nutrient from that soil). Knowing this basic information about your soil test methods will help with interpreting soil test values. How extractants compare and other factors behind soil testing are discussed in greater detail in Factsheet 3 of the Nutrient Management Factsheet Series: *Understanding Different Soil Test Methods.*

For each laboratory that provides its soil fertility testing services, default extractants are listed for soil phosphorus and potassium in the table below. In other words, when no specific method has been requested, these extractants have been used. Soil test users should confirm this information with their chosen laboratory. Laboratories may offer other methods depending on client needs and the laboratories' capabilities.

Table 1. Default methods (extractants) for available soil phosphorus (P) and potassium (K) tests of nutrient testing laboratories. Laboratories may offer additional methods.

Laboratory	P extractant	K extractant
Agrichem Analytical	Kelowna	Kelowna
A & L Canada Laboratories Inc.	Olsen (Bicarbonate)	Ammonium Acetate
	Bray 1	
ALS Laboratory Group (formerly Enviro-Test)	Modified Kelowna 94[a]	Modified Kelowna 94[a]
Brookside Laboratories Inc.	Mehlich 3	Mehlich 3
Exova (formerly Bodycote or Norwest)	Modified Kelowna 95[b]	Modified Kelowna 95[b]
MB Laboratories Ltd	Modified Kelowna 94[a]	Modified Kelowna 94[a]
Pacific Soil Analysis	Bray 1	Ammonium Acetate
Plant Science Lab	Mehlich 3	Mehlich 3
Soil Foodweb Canada	Mehlich 1	Mehlich 1

a. Qian, Schoenau and Karamanos (1994) proposed this extractant.

b. Ashworth and Mrazek (1995) proposed this extractant.

Table 2. Common soil test phosphorus and potassium extractants and their compositions.

Extractant	Chemical Composition
Ammonium Acetate	1.0 *M* CH_3COONH_4 at pH 7.0
Bicarbonate (Olsen)	0.5 *M* $NaHCO_3$ at pH 8.5
Bray 1	0.03 *M* NH_4F+ 0.025 *M* HCl
Kelowna	0.015 *M* NH_4F + 0.25 *M* CH_3COOH
Mehlich 3	0.015 *M* NH_4F + 0.2 *M* CH_3COOH + 0.013 *M* HNO_3 + 0.25 *M* NH_4NO_3 + 0.001 *M* EDTA
Modified Kelowna 94[a]	0.015 *M* NH_4F + 0.025 *M* CH_3COOH + 0.25 *M* CH_3COONH_4
Modified Kelowna 95[a]	0.015 *M* NH_4F + 0.5 *M* CH_3COOH + 1.0 *M* CH_3COONH_4

a. See footnotes in Table 1.

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Soil Sampling for Nutrient Management

Nutrient Management Factsheet – No. 2 in Series

Revised September 2010 – Order Reference No. 631-500-1

For nutrient management, soil sampling is done to collect a soil sample that represents the spatial area for which nutrient information (e.g. fertilizer recommendations) is needed. To do this many samples will be collected and mixed together to make one composite sample for each field. Any soil sample can be analyzed to give lab results but results are meaningful only if appropriate sampling and handling procedures are used. The results are used to help determine what level of additional nutrients, if any, are required.

Soil testing can be done for different purposes and the purpose affects the sampling depth and time of sampling among other considerations (**Table 1**). To use the Nutrient Management Planning (NMP) software produced for the Canada-BC Environmental Farm Plan program, soil samples should be taken for nitrogen, phosphorus and potassium for agronomic purposes. These elements are the focus of this factsheet.

Table 1. Recommended depths and times for sampling soil phosphorus, potassium and nitrate-nitrogen.

Component	Purpose	Phosphorus (P), Potassium (K)	Nitrate-Nitrogen (NO_3-N)
Time	Agronomic		
	- predictive	Pre-plant ('before growing season')	Humid with moderate winters: post-harvest ('after growing season') Dry with cold winters: pre-plant Forage corn: pre-sidedress
	- feed-back	Post-harvest	Post-harvest
	Environmental	Post-harvest	Post-harvest
	Monitoring	Consistent: pre-plant or post-harvest	Consistent: pre-plant or post-harvest
	Trouble shooting	Variable (depends on issue)	Variable (depends on issue)
	Characterization	Variable (depends on issue)	Variable (depends on issue)
Depth	General	0-15 cm (0-6")	0-30 cm (0-12")

When to Collect Soil Samples

Sampling frequency

Sample every field at least once every three years. Fields in perennial crops should be sampled before they are seeded or planted. Consider sampling more frequently if the soil is coarse-textured or if crops have been grown that are heavy users of nutrients, since nutrient and pH levels tend to change more frequently than in fine-textured soils.

More frequent sampling generates more data, making it easier to identify trends over time.

For soil nitrate-N, annual pre- and post-harvest testing is recommended for certain situations – see the *Feedback (agronomic) and environmental testing* section below.

Times of year

Check with the chosen lab about their turnaround time for soil analysis. Each type of sampling described below should occur at approximately the same time in each year of sampling to help distinguish seasonal and sampling variation from actual changes in soil nutrients.

Predictive (agronomic) testing

This testing looks forward in time. The following times are recommended for samples that can be taken before or during the growing season (for which nutrient application decisions are being made):

Pre-plant sampling in the spring is recommended. Samples should be collected before starting field work for annual crops and before a new flush of growth begins for perennial crops. These are the only results used in the current NMP software. Nitrate values are expected to be small at this time in south coastal BC.

- Post-harvest nitrate values from the previous fall, after active crop growth has stopped or minimized, can be substituted for pre-plant nitrate values (i.e. results can be used in the current NMP software) for soils of the Interior of BC (dry with cold winters), but not for soils of the south coast of BC (humid with moderate winters).

The Pre-Sidedress Nitrate Test (PSNT) is used to determine corn's sidedress nitrogen requirements. Soil samples are collected at the 6-leaf stage (usually mid-June), just before the crop takes up nitrogen rapidly. Although not used in the current NMP software, the PSNT is typically more reliable as a predictive test than pre-plant nitrate testing and should be considered to be a part of nitrogen management for corn. For more information, see the reference below.

Zebarth, B.J. 2004. Spring nitrogen tests *in* S. Bittman and G. Kowalenko (eds). Advanced Silage Corn Management. Available at http://www.farmwest.com/index.cfm?method=library.showPage&librarypageid=127

Feedback (agronomic) and environmental testing

This is testing that happens at the end of a growing season to help plan nutrient applications the next growing season. It is most useful for nitrogen when there is 1) a history of post-harvest nitrate results and related information (e.g. crop yield and quality, manure application rate and history, weather, etc.), and 2) the cropping in the field has and will be consistent (i.e. there is a perennial crop or the same annual crop grown will be grown). A post-harvest nitrate test and interpretations have been proposed for grass hay/silage and silage corn fields in south coastal British Columbia. For a full discussion of the use, interpretations and limitations of this test, see the following:

Sullivan, D.M and C.G. Cogger. 2003. Post-harvest soil nitrate testing for manured cropping systems west of the Cascades: available on the Oregon State University extension website at http://extension.oregonstate.edu/catalog

Very high post-harvest nitrate test values could indicate situations when nitrogen application rates could have been decreased or eliminated with low risk to the crop.

Post-harvest sampling is recommended for environmental testing because it examines the nutrients left in the soil after crop uptake and before the usual time of highest risk of transport into ground and surface waters. Nitrogen and phosphorus are the main nutrients of environmental concern.

Sampling for other purposes

Monitoring: If tracking nutrient trends across years, be consistent with respect to time, location and depth of sampling.

Troubleshooting or Characterization: If sampling to troubleshoot suspected nutrient-related problems or to complete a soil description, sampling times vary according to the specific issue and objectives of sampling.

Sampling Depth

Phosphorus, potassium (and ammonium-nitrogen)

The recommended sampling depth is 15 cm deep (6"). Most of the phosphorus and potassium are likely at this depth. Although cultivation can be variable, 0-15 cm will include the most common minimum of a mix layer. Soil nutrient test interpretations for British Columbia soils have been based on this sample depth.

Nitrate-nitrogen

The recommended sampling depth is 30 cm (12"). Note the approximate sample depth if you must sample at shallower depths. Plants usually root deeper than 15 cm and nitrate will move with water down the soil profile, so it is important to sample deeper than for phosphorus and potassium.

Tips for sample collection
Soil samples collected in perennial forage crops will have a layer of sod on top of the soil. Discard the top layer of dead leaves and roots above the mineral soil but not the roots that extend into the soil.

When sampling in newly worked bare land, gently press down the soil with your boot before sampling to more accurately mimic the settled soil depth.

Where to Sample

The objective is to ensure that a soil sample represents the area for which nutrient information is needed. Location of sampling is more important for phosphorus and potassium (and ammonium) than for nitrate; over time, the banding effect of nitrogen fertilizer will decrease.

Before soil sampling, consider the variability within each field. There may be variability due to differences in manure or fertilization history, topography, drainage, eroded areas, sandy vs. clay-rich areas, or sections of a field that have previously been farmed separately over the years.

Unusual areas should be avoided for routine sampling or they should be sampled separately. These include small, low, wet areas; dead furrows; areas close to trees, roads and fences; manure piles; fertilizer storage; and livestock droppings.

Use the information about the variability across your fields to create a field management map. Group sections that will be managed uniformly (i.e. fertilizer spread at a constant rate) into a sampling unit. Sampling units should be no more than 10 hectares (25 acres) or they can be larger if the characteristics and management of the field is known to be uniform. Assign a number or name to each sampling unit. Keep the same sampling units after the first year of sampling unless fields will be split. Record all pertinent information about the areas sampled. This information should include cropping history and desired crops to be grown, recent fertilizer or soil amendment applications, livestock use and any other relevant information about the site.

Where nutrients are broadcast (applied uniformly)

In each field or sampling unit, samples should be collected using a random or zig-zag pattern. **Figure 1** shows an example of a random soil sampling pattern (shown in yellow) and areas to avoid (shown in pink).

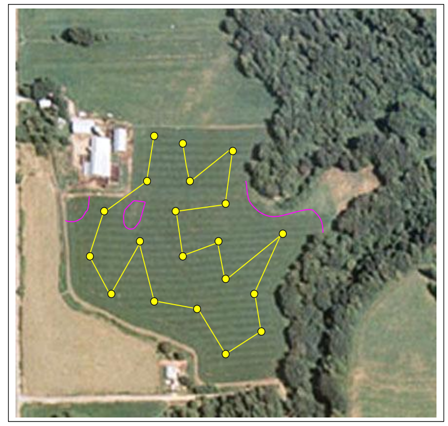

Figure 1. Random soil sampling pattern

Where nutrients are applied in bands

Sampling methods from the post-harvest phase of the Fraser Valley Soil Nutrient Study 2005 and Okanagan Agricultural Soil Study 2007 are described below. These methods can be adapted for agronomic soil testing. Ultimately, you may choose a specific sampling method for which you have most historical data for the fields being sampled.

The Fraser Valley Soil Nutrient Study 2005 and Okanagan Agricultural Soil Study 2007 reports are available at, http://www.agf.gov.bc.ca/resmgmt/EnviroFarmPlanning

Corn: If the location of the phosphorus fertilizer band is known, take samples at random locations between the fertilizer bands. If the location of the fertilizer band is unknown, take 30 to 40 cores per field from random locations or about twice as many as cores as for fields without fertilizer bands.

Raspberries: take pairs of samples (1) and (2) (**Figure 2**):

1) the centre of the fertilizer band between the plants along the crop row
2) the centre of the cultivation/root mound between plants in the crop row

Blueberries: take pairs of samples (1) and (2) (**Figure 3**):

1) small plants - outside the drip line OR
1) large plants - midway between plants in the row
2) base of raised bed between plants and inter-row

Tree Fruits and Grapes: take samples at random locations from within the drip line of the tree or vines.

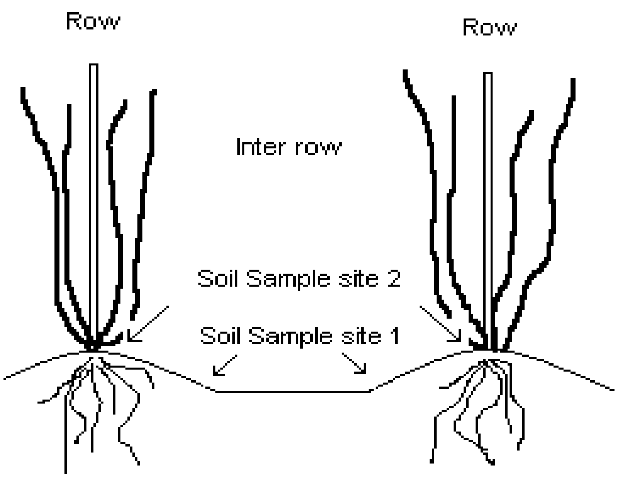

Figure 2. Sampling locations for raspberries

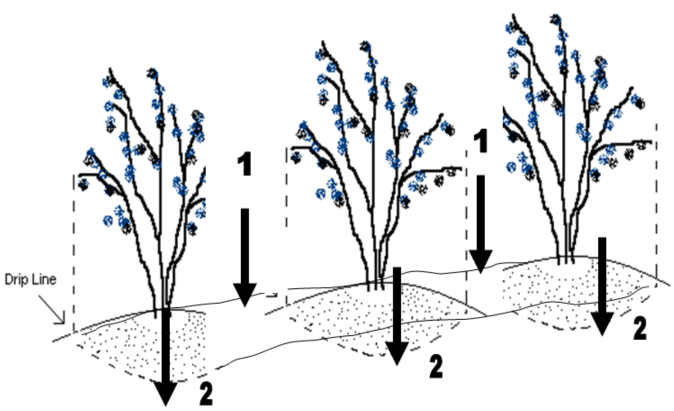

Figure 3. Sampling locations for blueberries

Sampling Equipment

A soil sampling probe (tube) or auger is recommended. A soil probe (**Figure 4**) works best in well cultivated soils without rocks but is difficult to use in rocky, very dry or very wet soil. An auger is better for less well cultivated or rocky soils.

If the soil texture is very coarse or there are many coarse fragments, a shovel can be used instead of a soil sampling tube or auger. When sampling with a shovel, make a V-shaped hole where the sample is to be taken. Take a 2-3 cm (1 inch) thick slice down one side of the hole to 15 cm (6"), and trim the slice to form a 2-3 cm (1 inch) wide core (**Figure 5**). Lift out the soil slice and place it into the sample bucket.

Figure 4. Soil probe

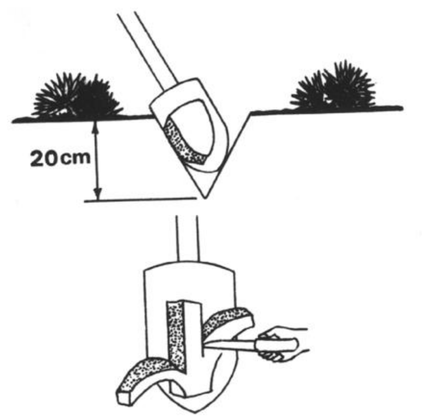

Figure 5. Shovel method of soil sampling

Ensure that the sampling equipment is clean. If sampling for micronutrients or metals, ensure there is no rust on it to prevent contamination. Latex gloves will prevent contamination from hands. A plastic bucket or clean bag in a bucket would be ideal to hold soil samples in the field.

Sample Handling

Composite samples are the mixtures of numerous individual samples that will represent a sampling area. To make a composite sample, collect at least 15 soil cores (or slices) in each sampling area. The recommended maximum area is 10 hectares (25 acres) per 15 cores. Place all cores in a clean plastic pail or container. About 0.5 kg (1 lb) is usually more than enough.

Then the sample must be mixed well and precautions need to be taken to minimize changes before lab analysis. There are two options to do this:

1) Keeping the soil cool (but not frozen)
This assumes the sample is dry enough to be mixed well. After mixing the composite sample well, fill a bag or other clean container with soil. Clearly label samples with the date, field or sample unit name, and sampling depth (0-15 cm or other). Keep the samples cool (e.g. refrigerated in a cooler but not frozen) until they reach the lab and they should reach the lab as quickly as possible. Freezing soil samples is not recommended as soil nitrogen can change forms while freezing/thawing.

2) Air drying the soil
Keep samples cool as described above until they can be spread on plastic sheets in a clean, ventilated room at room temperature. Dry thoroughly for one to two days, and then mix each sample well and send to the lab in clean and labelled containers.

Ideally, prepare samples for analysis after drying and before sending to the lab: crush the dried soil, screen (sieve) it and then mix it well. Then you can send part of a sample to the lab and save another part for your own reference sample, in clean and labelled containers.

A significant advantage of air drying before sending to the lab is the ability to save some reference samples, since the nutrients in air-dried soil samples will be stable for many years. Keeping some reference samples would be useful if you want to compare different labs' results or evaluate the analysis quality of a lab.

For a soil sample to be mixed thoroughly before it is analyzed, it is easiest to do this when the sample is dried first. Splitting a soil sample to send to different labs is not recommended unless it is first air-dried and mixed well.

Lab Analyses to Request

To use the NMP software, the following soil test information is needed for a pre-plant soil sample taken in the spring:

- nitrate-nitrogen (NO_3-N)
- available phosphorus (P)
- available potassium (K)

In addition, ammonium-nitrogen (NH_4-N) is recommended.

To be able to better interpret lab results, find out the lab methods for soil test phosphorus and potassium. See Factsheets 1 and 3 in the Nutrient Management Factsheet Series for more information.

Commercial laboratories usually have soil fertility packages that will include the above analyses as well as other parameters including soil pH and other nutrients. Keep this information in your records.

To use the NMP software, the fertilizer recommendations on a lab report are not required.

Questions and Answers

1. Why is nitrate (NO_3) sampled differently from P and K?

It has to do with the behaviour of the nutrients in terms of how prone each nutrient is to being moved through soil. Whereas P and K are relatively immobile, NO_3 is easily leached or moved through soil by water (rain or irrigation).

2. Why does sampling time matter?

Most correlation and calibration research for developing soil tests and interpretations were done with pre-plant samples. As the time of sampling is done further before planting time, as in the previous fall, possible changes by climatic conditions need to be considered. Nitrate is assumed to move down the soil profile with rain or irrigation. Some research suggests that phosphorus does not change significantly over the winter in the Lower Fraser Valley, whereas potassium has been found to increase in some cases.

3. What if different sample depths are used?

Fertilizer recommendations were developed using the recommended depths in **Table 1**. Immobile nutrients (P and K) are considered separately from mobile nutrients (NO_3).

Immobile nutrients
For immobile nutrients, if a sample deeper than 15 cm is taken, the nutrient concentrations will likely be lower and the fertilizer recommendations greater. This is because of lower concentrations at subsurface depths. For example, in the Fraser Valley Soil Nutrient Study of 2005, phosphorus was on average 45% lower in the 15-30 cm depth than the 0-15 cm depth, and potassium was 32% lower.

Kowalenko, C.G., Schmidt, O. and Hughes-Games, G.A. 2007. Fraser Valley soil nutrient study 2005. A survey of the nitrogen, phosphorus and potassium contents of the Lower Fraser Valley agricultural soils in relation to environmental and agronomic concerns.
http://www.agf.gov.bc.ca/resmgmt/EnviroFarmPlanning/FV_SoilNutrientStudy/_FVSNS-CombinedReport_Feb28_2007_for_Release.pdf

If a sample shallower than 15 cm is taken, it will not make much difference to P and K concentrations if the surface soil has been cultivated to at least 15 cm; if there was minimum tillage (e.g. perennial grass), shallower sampling would result in higher soil nutrient concentrations and lower fertilizer recommendations.

Mobile nutrients
For mobile nutrients, a deeper sampling depth becomes more important if there has been leaching after harvest. If rain washes soil nitrate below 30 cm before a post-harvest nitrate sample is taken, a sample from 0-30 cm would indicate no residual nitrogen – a false interpretation of the actual situation.

4. How do sampling locations in fertilizer-banded fields affect results?

Increasing the proportion of sampling locations from or near the fertilizer bands will increase the soil test values of nutrients (particularly immobile nutrients like phosphorus and potassium) for the field. This would mean that the fertilizer recommendation will be lower. Since the plants will probably feed mostly from the banded areas, i.e. use the fertilizer more efficiently, the fertilizer recommendation would be more appropriate. However, if you do not take enough cores to make your composite sample, soil samples that include (rather than exclude) the fertilizer band have the greatest deviation or variation from the 'true' values.

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Understanding Different Soil Test Methods

Nutrient Management Factsheet – No. 3 in Series

September 2010 – Order Reference No. 631.500-9

Soil test results from different laboratories can be quite different for what seems to be the same soil sample, like when a sample is split to be analyzed by more than one lab. One explanation is that the labs actually received different samples. This can happen if the original soil sample is not mixed thoroughly before it is split and if the subsamples are not preserved well before they reach the lab(s). See the *Sample handling* section of Factsheet 2, *Soil Sampling for Nutrient Management,* for more information. Nonetheless, two labs that are 'doing everything right' can provide different values for the same nutrient of interest because of differences in the soil test methods between the labs.

This factsheet provides information to compare soil test results of different methods. Simple conversion factors are provided to help compare results of common phosphorus (P) and potassium (K) methods or 'extractants' to be more specific. These conversions are built into the Nutrient Management Planning (NMP) software produced for the Canada-BC Environmental Farm Plan program.

Because various factors of test methods can influence results, this factsheet first outlines some of the key factors behind conventional soil test P and K methods and notes for understanding the simple conversion factors.

Key Factors of Soil Test Methods

A conventional soil nutrient test method has the following factors:

- **the extractant**
- weighing versus scooping (by volume) soil
- soil to extractant ratio
- soil extraction time
- extraction temperature
- **the quantification method**

The extractant

An extractant is a chemical solution that is added to a soil sample to 'dissolve, desorb or exchange' a portion of the total amount of a given nutrient(s) in the soil sample. This portion should provide a crude but useful index of the portion of a nutrient in soil that will be available to a crop through soil processes. In contrast, a measure of the total amount of an element is in a sense, a more crude measurement because it is not meant to distinguish between portions of a nutrient, some of which are plant-available and some of which are not.

Some extractants were developed for a single nutrient or element; others for multiple nutrients or elements. For any particular nutrient (e.g. phosphorus), different extractants may remove different portions of the nutrient, because each extractant was originally developed for a different soil type or purpose.

The extractant is the main factor considered in the NMP software and in the conversion factors between common extractants provided below (**Tables 1 and 2**).

The quantification method

A quantification method determines the amount of a nutrient(s) in the extraction solution after the nutrient(s) has been extracted from a soil.

Some quantification methods are non-selective and measure the total amount of a nutrient element(s), *i.e. inorganic + organic*

- e.g. Inductively Coupled Plasma (ICP)

Others are selective and measure a fraction of the total amount of a nutrient in a specific molecular form, *i.e. inorganic*

- e.g. colorimetry
- e.g. ion chromatography

Some colorimetric methods have unavoidable interference problems that can result in under- or over-estimates of the true values, and the error varies between soils[1,2]. This interference means that measurements are only 'sometimes right.' This affects P (and sulphur) measurements in particular. It should not affect soil K measurements (since organic K compounds do not occur).

To use the NMP software, soil test results should be treated as roughly equivalent at this time for all quantification methods unless otherwise indicated. In other words, there is no need to know the laboratory's specific quantification method: just be aware that it is one other factor of the soil test besides the extractant that can explain differences in soil test (phosphorus) results.

Relationships between Extractants for Soil Phosphorus and Potassium

A recent study compared results of common soil test extractants for soil P and K. Highlights are presented below. Please refer to the full report[3] for more information.

Methods

The extractants in **Table 1** were used to determine soil test P and K contents of a total of 990 soil samples collected during the Fraser Valley (2005)[4] and Okanagan-Similkameen (2007)[5] soil studies representing a broad range of soil types and nutrient levels in the two regions. Soil to extractant ratio (1:10 w/w) and soil extraction time (5 minutes) were standardized for all extractants except bicarbonate (1:20 w/w and 30 minutes instead), and quantification was by ICP for all extractants.

In British Columbia, the Kelowna extraction method was the last provincial standard publicly developed for soil phosphorus and potassium testing for agronomic purposes[6]. Thus, the relationships in Tables 1 and 2 are comparisons between the Kelowna extractant and other extractants.

Results

Disclaimers:

- The relationships in **Table 1** may not apply exactly to commercial laboratories' results because the relationships are effectively a comparison of *extractants'* abilities to extract P. They are not a comparison of specific laboratories' methods, which are difficult to compare since they vary in the factors of a soil test method (soil-to-extractant ratios, extraction times, and quantification methods) for the same extractant.
- The relationships in **Table 2** are expected to produce reliable estimates for soil test potassium.
- The relationships indicate how well the Kelowna extractant compares with other extractants. However, the study was limited in the sense that it was not designed to indicate how well different extractants reflect the response of crops to additional fertilizer.

Example calculation:

A result of 86 ppm P (Bray-1 method) in a soil of pH 5.3 is approximately equivalent to 64 ppm P (Kelowna method) according to Table 1, which is approximately equivalent to 51 ppm P (Modified Kelowna-95 method)[7].

Table 1. Relationships between soil test P extractants and the Kelowna extractant for British Columbia soils.

Kelowna-P = **0.74** * Bray-1 P	pH < 7.2	$r^2 = 0.96$
Kelowna-P = **1.00** * Bray-1 P	pH ≥ 7.2	$r^2 = 0.85$
Kelowna-P = **0.99** * Bicarbonate (Olsen) P	pH < 7.2	$r^2 = 0.99$
Kelowna-P = **1.21** * Bicarbonate (Olsen) P	pH ≥ 7.2	$r^2 = 0.96$
Kelowna-P = **0.72** * Mehlich-3 P	all pH values	$r^2 = 0.98$
Kelowna-P = **1.24** * Modified Kelowna-95 P[7]	all pH values	$r^2 = 0.96$

[7] Ashworth and Mrazek 1995.
At the time of writing, the Exova laboratory in Edmonton, AB (formerly Bodycote) used this soil test P extractant.

An alternative relationship between Kelowna-P and bicarbonate-P is recommended to be used by the default (i.e. unless the laboratory is known to use ICP for the bicarbonate-phosphorus measurements, use the following):

Kelowna P = **2** * Bicarbonate (Olsen) P-colorimetry

Rationale: Most commercial laboratories use colorimetry instead of ICP to quantify phosphorus for bicarbonate extractions, which in turn is a common extraction for calcareous soils. The alternative relationship does not come from the study that produced results in Table 1. It is based loosely on results of previous studies[8,9] that cannot be directly compared because of differences in methods, particularly the use of interference-prone colorimetry. The colorimetry distinction is made only for bicarbonate because compared to the other extractants in Table 1, it is in its own 'family' of chemical solutions and has been found to extract more organic P[3].

What do the r^2 values mean?

Greater r^2 values indicate a 'stronger' relationship. Values can range from 0 (no relationship) to 1 (perfect relationship). The bicarbonate-Kelowna P relationship (Figure 1) is 'weaker' than the Mehlich 3-Kelowna P relationship (Figure 2) for most soils, as shown by a greater spread of data points around the line for the 'bicarbonate' graph compared to the 'Mehlich 3' graph.

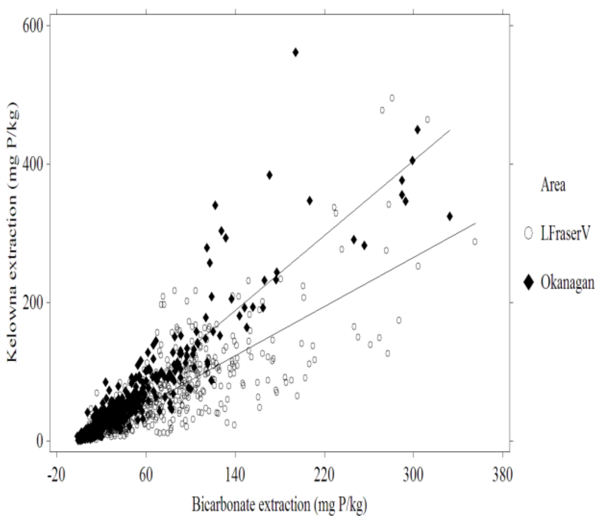

Figure 1. Bicarbonate P vs. Kelowna P for soil samples from the Lower Fraser Valley and Okanagan-Similkameen of BC.

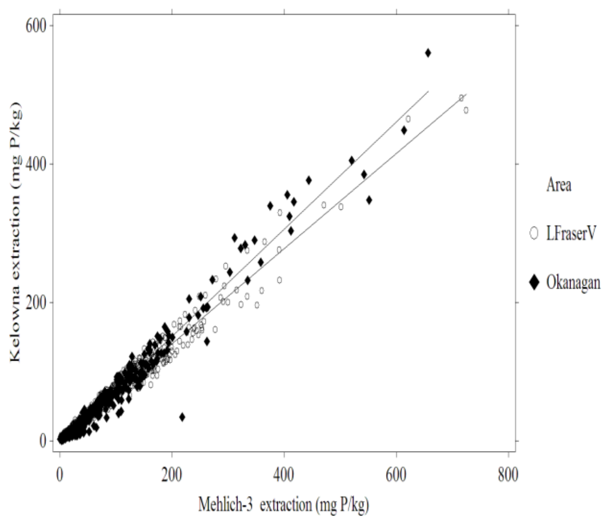

Figure 2. Mehlich3-P vs. Kelowna P for soil samples from the Lower Fraser Valley and Okanagan-Similkameen of BC.

Table 2. Relationships between soil test K extractants and the Kelowna extractant for British Columbia soils.

Kelowna-K = **0.80** * Ammonium Acetate K	all pH values	$r^2 = 0.98$
Kelowna-K = **0.75** * Mehlich-3 K	all pH values	$r^2 = 0.99$
Kelowna-P = **0.76** * Modified Kelowna-95 K[7]	all pH values	$r^2 = 0.97$

[7] Ashworth and Mrazek 1995.
At the time of writing, the Exova laboratory in Edmonton, AB (formerly Bodycote) used this soil test K extractant.

Converting between ppm and kg/ha

To convert between "parts per million" (ppm) and "kilograms per hectare" (kg/ha) requires values for the soil bulk density (in kg/m^3) and the depth of the soil layer sampled (in metres). The following are rules of thumb for mineral soils that assume soil bulk density is 1000 kg/m^3.

1) Converting ppm to kg/ha
If sample depth was 0.15 m (15 cm or 6 inches),
then Value in kg/ha = Value in ppm x 1.5
Rationale: Value in kg/ha = Value in ppm x (1 kg/10^6 mg) x (1000 kg/m^3, bulk density) x (0.15 m x 10^4 m^2/ha)

Example: 50 ppm P = approx. 75 kg P/ha

2) Converting kg/ha to ppm
If sample depth was 0.30 m (30 cm or 1 foot),
then Value in ppm = Value in kg/ha ÷ 3.0
Rationale: Value in ppm = Value in kg/ha ÷ (1 kg/10^6 mg) ÷ (1000 kg/m^3, bulk density) ÷ (0.30 m x 10^4 m^2/ha)

Example: 200 kg N/ha = approx. 67 ppm N

You may choose to use a different value than 1000 kg/m^3 to convert your values. Average soil bulk densities for mineral soils are as follows:

Well structured high organic loam soil	900 kg/m^3
Silt loam	1100 kg/m^3
Medium to fine texture loam	1300 kg/m^3
Sand	1500 kg/m^3
Compacted soil or clay subsoil	1300-1600 kg/m^3

For mineral soils, a soil test value on a weight basis (mg/kg or µg/g) is roughly the same as on a volume basis (mg/L or µg/mL). Because bulk densities for Organic soils vary widely (e.g. 100-700 kg/m^3), this assumption should not be made for Organic soils, and thus the rules of thumb described for converting between ppm and kg/ha should not be used.

References

1. Kowalenko, C.G. and Babuin, D. 2007. Interference problems with phosphoantimonylmolybdenum colorimetric measurement of phosphorus in soil and plant materials. Communications in soil science and plant analysis 38: 1299-1316.
2. Kowalenko, C.G. 2008. Extraction times and analysis methods influence soil test measurements of phosphorus and sulphur. Canadian Journal of Soil Science 88: 733 – 747.
3. Kowalenko, C.G. 2010. Relationships between extraction methods for soil nutrient testing in British Columbia. Report for Ministry of Agriculture and Lands. http://www.agf.gov.bc.ca/resmgmt/EnviroFarmPlanning/Relationships_Between_Extraction_Methods.pdf
4. Kowalenko, C.G., Schmidt, O. and Hughes-Games, G.A. 2007. Fraser Valley soil nutrient study 2005. A survey of the nitrogen, phosphorus and potassium contents of the Lower Fraser Valley agricultural soils in relation to environmental and agronomic concerns. http://www.agf.gov.bc.ca/resmgmt/EnviroFarmPlanning/FV_SoilNutrientStudy/_FVSNS-CombinedReport_Feb28_2007_for_Release.pdf
5. Kowalenko, C.G., Schmidt, O., Kenney, E., Neilsen, D. and Poon, D. 2009. Okanagan Agricultural Soil Study 2007. A survey of the chemical and physical properties of agricultural soils of the Okanagan and Similkameen Valleys in relation to agronomic and environmental concerns. http://www.agf.gov.bc.ca/resmgmt/EnviroFarmPlanning/OK_AgricSoilStudy2007/Okanagan_Soil_Study_Report_2007.pdf
6. Gough, N.A. 1991. (Republished in 1996.) Soil and plant tissue testing methods and interpretations of their results for British Columbia agricultural soils. Final draft report.
7. Ashworth, J. and Mrazek, K. 1995. “Modified Kelowna” test for available phosphorus and potassium in soil. Communications in Soil Science and Plant Analysis 26: 731-739.
8. van Lierop. W. 1988. Determination of available phosphorus in acid and calcareous soils with the Kelowna multiple-element extractant. Soil Science 148: 284-291.
9. Ige, D.V., Akinremi, O.O., Flaten, D., Haluschak, P. and Eilers, B. 2005. Comparison of agronomic soil test P methods for Manitoba soils. Poster presentation. http://www.gov.mb.ca/agriculture/msss/2005/mss650.pdf

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Forage Crop Sampling for Nutrient Management

Nutrient Management Factsheet – No. 4 in Series

Revised September 2010 – Order Reference No. 631.500-2

This factsheet describes the steps to collect representative forage crop samples that will be analyzed for dry matter content and nutrient concentrations.

To develop a nutrient management plan, the crop nutrient requirements must be estimated. Crop nutrient requirements depend on dry matter yield and nutrient concentrations (of nitrogen, phosphorus and potassium). These values can be estimated but the plan will be more reliable if the values are farm-specific.

To get accurate analytical data, the crop samples collected must be typical of the whole crop. Representative crop samples should be collected and analyzed at each crop harvest. Results are used to monitor the effectiveness of the current year's plan and to help predict the crop nutrient requirements of next year's crop.

Sample Collection

Silage (grass or corn): Collect 10-15 samples (one handful per sample) from each field at the time of forage harvest, and mix samples together in a clean plastic bucket. Collect samples while the silage is being unloaded. Collect one sample per load, unless there are less than 10 loads from a field, in which case take two samples per load. Fill a freezer bag or 1 L plastic container with the sampled material.

Hay Bale Sampling: Hay is most accurately sampled using a hay corer. You can take samples by hand (i.e. grab samples) instead if there is no corer, but the proportion of stems to leaves cannot be as well represented, especially for alfalfa.

If using a hay corer or probe (**Figures 1 and 2**), it must have a tip sharp enough to cut through the hay. It must have an internal diameter of at least 1 cm (3/8 inch), and it must be long enough to extend into the middle of a large round bale. When sampling a square bale, insert the corer into the middle of one end of the bale and drill into the middle of the bale (**Figures 2 and 3**).

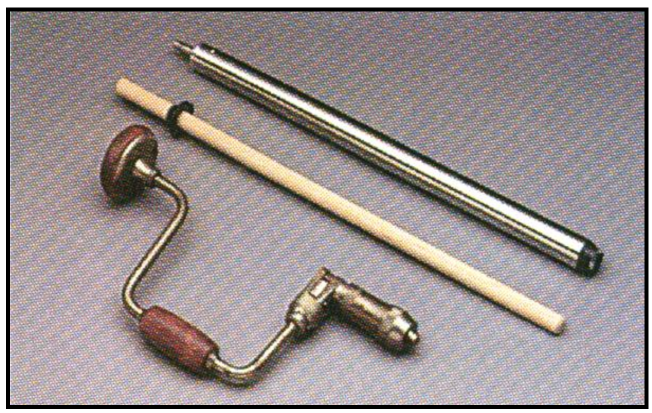

Figure 1. Hay corer

Figure 2. Collecting a core from a square bale

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On round bales, insert the corer into the round part of the bale (as opposed to one of the flat sides) and drill into the middle. Collect cores from at least 10 bales from each field to make a composite sample. Because hay is difficult to mix and subsample accurately, submit all cored material to the lab.

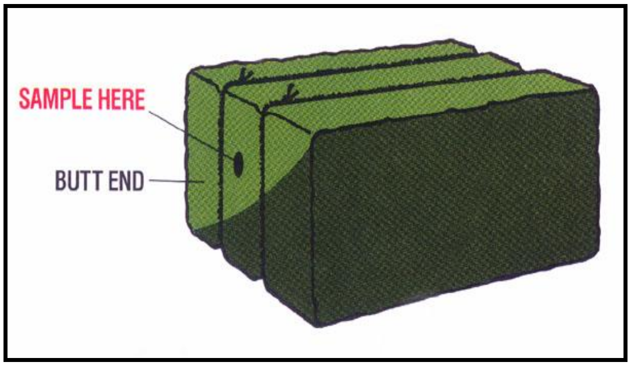

Figure 3 Bale sampling locations

If hand-collecting samples, sample as accurately as possible the proportion of stems to leaves. As grass hay fractures less during baling than alfalfa, it is easier to get a representative hand sample from grass. Open each bale and take a grab sample from the middle – one handful per sample. Sample at least 10 bales from each field. For large round bales, use the field sampling procedure below.

Field sampling: Hay should be sampled in the field just before baling. Collect 10 grab samples (one handful per sample) from the inside of the swath equally distributed throughout the field. Collect samples in a plastic bag and close tightly when sampling is complete. Submit the whole sample to the lab.

When Should Samples be Collected?

Silage: Collect samples from each cut of silage as it is being produced. Samples can be frozen and submitted together following the final cut of silage or submitted following each cut. Once average values have been established for forage and corn silage produced on the farm, sampling frequency can be reduced.

Hay: Sample hay either as it is being produced in the field, or after harvest. Sampling can occur anytime if the hay from each field can be identified. It may be simpler, however, to sample hay from each field before it is mixed in with other hay lots.

When to Group Fields Together

Collect a separate sample from each field if the age, species composition or fertility is different from all other fields. If several stands are the same age, species and have had the same management since establishment, the forage from them can be sampled and submitted to the lab as one sample. The forage quality information from the sample will then apply to all the fields that made up the sample.

Handling and Labeling Samples

Samples should be stored in a tightly sealed plastic freezer bag or container. Send samples to the lab in a refrigerated container. Try to ensure that samples arrive at the lab on a weekday and do not get delayed over a weekend en route.

Label each sample with the sample date, field(s) from which the sample was taken, the forage type, and your name or the farm name. A good labeling method for moist samples (such as silage) is to double bag the sample, and then slip a paper label between the two bags. Alternatively, a paper label on a string can be tied to the bag. Paper labels placed in with silage will disintegrate and information marked on a plastic bag can rub off.

What Analyses are Required?

To use the Nutrient Management Planning software produced for the Canada-BC Environmental Farm Plan program, forage samples should be analyzed for the following parameters:

- crop protein
- phosphorus
- potassium
- moisture

If the analysis will also be used for determining livestock feed rations, other parameters such as nitrates, acid detergent fibre, and neutral detergent fibre may also be desired.

Interpreting Crop Lab Reports

Crop protein content: The lab will provide the percent protein content on a dry basis. You should use this value.

Crop moisture or dry matter content: The lab report will contain the crop moisture or dry matter content as a percentage of the total sample weight. The dry matter percentage is then multiplied by fresh matter yield to determine the total dry yield (see step (d) of Table 1). The dry yield is used to estimate the crop's nutrient requirements.

Calculating Crop Dry Yield

Silage: To determine total dry yield, start by finding out the loads of silage taken off each field (from all cuts), the average weight per load and the dry matter percentage. Then follow steps (a) to (d) in Table 1.

It may be possible to verify the average weight of a silage load by using a local drive-on scale. Feed and fertilizer plants, lumber mills and occasionally large intensive livestock operations have drive-on scales. Weigh at least three typical loads of silage – either the silage wagon itself or the truck used to haul silage to storage. Subtract the vehicle empty weight from the vehicle plus silage weight to get the wet weight of silage. Weigh all the different types of bulk moist feed grown (haylage, corn or grass silage).

Alternatively, a rough estimate of the weight of a silage load can be obtained by knowing the volume of the high-dump or truck. On average, silage weighs 5 pounds per cubic foot, regardless of whether it is fresh or partially dried before ensiling, or corn or grass silage. Multiply volume (cubic foot) by 5 (pounds per cubic foot) to estimate weight in pounds. Many types of silage high-dumps have the volume indicated on the side or in the manufacturer's manuals. The volume of the high-dump can also be estimated by multiplying height by width by length.

Hay: Total 'as produced' yield of hay per field is determined by multiplying the average weight per bale by the total number of bales produced from each field over the season. The weight of small square bales is relatively uniform; however, round bale weights vary significantly. You should weigh at least 10 to 15 bales to get a reliable average weight.

The 'as produced' values (or wet yields) should be corrected to 'dry yields' (as in step (d) in Table 1). If the dry matter of the farm's hay has not been measured, use the average value of 90% dry matter (10% moisture).

Conversions
Weight (kg) = Weight (lbs) x 0.45
Tonnes per ha = Tons per acre x 2.25

Table 1. Determining dry matter yield (assuming 29 loads/field, 6035 kg/load and 35% dry matter)

Step	Calculation	Example
a	# loads from field (all cuts for year) x kg/load = total wet yield (kg) from field	29 loads from field x 6035 kg/load = 175,000 kg wet weight of silage
b	total wet yield (kg) / field size (ha) = total yield/ha (kg)	175,000 kg / 5 ha = 35,000 kg/ha wet weight
c	total wet yield (kg/ha) / 1000 = total yield (tonnes/ha)	35,000 kg/ha / 1000 = 35 tonnes/ha wet weight
d	total wet yield (t/ha) x (dry matter%* /100) = total dry yield (t/ha)	35 t/ha x (35/100) = 12.25 t/ha dry yield

* dry matter% = 100 – moisture content, e.g. if moisture content = 67%, dry matter = 33%

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Manure Sampling and Analysis for Nutrient Management

Nutrient Management Factsheet – No. 5 in Series

Revised September 2010 – Order Reference No. 631-500-3

This factsheet describes the steps to collect representative manure samples that will be analyzed for their nutrient concentration.

If manure is being used as a nutrient source, a nutrient management plan strongly recommends the collection and analysis of representative manure samples. For that reason, careful sampling is very important.

Sample Collection

Liquid Manure (slurry)

Take at least 5 manure samples of ½ to 1 litre each from around the pit. Two sampling methods are acceptable

- **Method 1: (Figure 1)** Insert a long piece of PVC pipe into the manure as deep as it will reach and cap or cover the end. Manure will be held in the pipe as it is lifted from the pit. Empty each sample into a plastic pail. There is no need to mix or agitate the manure storage facility with this method.
- **Method 2: (Figure 1 insert)** Agitate pit thoroughly to mix. Dip a small pail (1/2 litre) nailed onto a pole into the pit at 5 different spots around the pit, and empty each sample into a clean plastic pail.

Mix and subsample: Mix the contents of the pail thoroughly and pour a subsample into a ½ or 1 litre plastic screwtop container. Do not fill container more than ¾ full, particularly if samples will be frozen. Screw lid on tightly. Place the container in a plastic bag and close tightly.

Label: Write the date, time, pit name, manure type and farm name on the bottle for lab identification and your records.

Figure 1. Liquid manure sampling

Lagoon sampling: It is not necessary to agitate lagoon liquid if the pit will only be partially emptied. Use method 1 or 2 above, but sample only the liquid that is to be applied. For example, if the top 4 feet will be spread, sample to that depth using the same methodology as for manure pits.

Solid Manure

Collect 5 to 10 samples from around the pile of solid manure, digging into the pile slightly to avoid weathered and dry material on the pile surface (Figure 2). Place all the samples in a plastic pail.

Mix and subsample: Mix the samples very well, chopping if necessary to blend the material. Fill a heavy plastic freezer bag or a ½ or 1 litre plastic screw top container ¾ full with manure and tightly seal. Place the container in a plastic bag and close tightly.

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Figure 2. Solid manure sampling

Label: Write the date, time, manure type, pile location and farm name on the bottle for lab identification and your records.

Sampling Handling and Shipping

Samples must be kept cool and transferred to the lab immediately. The nutrient composition of the sample may change if the manure is stored in a warm environment for longer than a few hours.

If samples cannot be sent to the lab until the following day, refrigerate or place them in a cooler on ice. Freezing is not recommended because of the changes in nitrogen that can happen when samples thaw. If shipping manure samples by courier or bus, ensure that they will not be stranded over a weekend en route.

Frequency of Manure Sampling

Slurry storage: The concentration of nutrients in uncovered slurry storage will change throughout the year because the amount of rainwater diluting the slurry changes with the season. For this reason, manure from this storage type should ideally be sampled several times throughout the year to ensure that nutrient application rates are accurate.

The manure will be most dilute in early spring, and should be sampled shortly before the major applications onto perennial forages and annually cropped land.

During the summer months, manure will be more concentrated as rainfall is low. Resample manure two or three times throughout the summer and fall months before applying manure on grass. If these samples are all very similar in nutrient content, one annual sample from the pit during summer months should be sufficient, as well as one sample taken before application each spring.

Solid manure piles: Sample each large pile before spreading. If, over several years of sampling, it appears that the nutrient content of the solid manure does not change significantly, the average nutrient content can be used.

What Analyses are Required?

Manure samples should be analyzed for the following parameters to use the Nutrient Management Planning (NMP) software produced for the Canada-BC Environmental Farm Plan program:

- total nitrogen (N or TKN)
- ammonium or ammonia (NH_4-N)
- total phosphorus (P)
- total potassium (K)
- total solids or dry matter (TS or DM), or moisture (MC)

Most labs offer manure analysis packages which also include some secondary nutrients and micronutrients. This additional information is useful for your farm records but is not required to use the Nutrient Management Planning (NMP) software produced for the Canada-BC Environmental Farm Plan program.

Interpreting Manure Lab Analyses

Units used to express manure nutrient value: In the lab, the sample is completely dried, and the amount of moisture and solids is determined from the difference between the sample weight wet and dry. Then the analyses for nitrogen, phosphorus and potassium are done, and the amount of each nutrient is determined on a dry basis (as if all of the moisture in the sample has been removed).

The moisture content of manure can vary widely depending on rainfall, wash water etc. so it is often more meaningful to look at nutrient content on a dry basis. Some labs leave the nutrient information on a dry basis (as a percentage of dry weight), while others convert it back to wet weight (kg/tonne or lb/ton) or units of volume (kg/m^3 or lb/1000 gallons).

Substances that are found in very small quantities such as micronutrients (copper, zinc) are expressed on a gram per kg of dry manure or 'parts per million' basis (ppm, or ug/g or ug/mL). Ammonium is also expressed on a 'ppm' basis although it makes up a significant amount of the total nitrogen of manure.

To use the NMP software, manure values must be entered in units of kg/tonne of wet (or 'as produced' or 'as received) manure. All lab units can be converted to wet weight using conversion factors in **Table 1**.

Total nitrogen (N) or TKN: A typical lab analysis for nitrogen in a manure sample is total Kjeldahl nitrogen or TKN. This lab method measures the organic nitrogen and ammonium-nitrogen (NH_4-N) fractions of manure, the two fractions that make up most of the nitrogen in manure.

Ammonium-nitrogen (NH_4-N): The other typical analysis for nitrogen in a manure sample is the measure of ammonium-nitrogen. The ammonium fraction is as crop-available as fertilizer nitrogen while the rest of the nitrogen in a manure sample is mostly contained within organic matter and is not immediately available for crop uptake.

Organic nitrogen: This value is typically not measured but calculated by taking the difference between the amount of total nitrogen and the ammonium fraction.

Total phosphorus (P): This measure is the typical lab analysis for phosphorus in a manure sample. Only a portion of the total phosphorus in manure will be crop-available in the year of application; the rest is bound in organic and inorganic substances and much of it is released into crop available forms in subsequent years. About 50% of the total P is crop-available in the year of application at low to moderate soil P levels; at higher soil P levels, more of the manure P is available in the year of application.

Total potassium (K): This measure is the typical lab analysis for potassium in a manure sample. Almost all the potassium in manure is readily available to crops.

Total solids or dry matter content : In this simple lab test, all moisture is removed from the manure sample by drying. The total solids or dry matter content of the manure sample is calculated from the wet and dry weights of the sample. This lab determination is only required if the lab does not provide the manure nutrient content in kg/tonne of 'as-produced' or wet manure. See Table 1 for examples of converting nutrient contents on a dry basis to nutrient contents on a wet basis.

Manure Quick Testers

There are several manure nutrient quick testers available for on-farm use. One of the main advantages of quick testers is that once the initial investment has been made, testing is cheaper than a lab test. Another advantage is that test results are available immediately.

Nova or Agros meter: This is the most common type of quick tester. It uses a quick chemical reaction to estimate the amount of ammonium in a manure sample. It provides an accurate estimate of ammonium content if the test is performed carefully.

It is most useful when ammonium is the major component of the total nitrogen in the manure, as with liquid dairy and hog manure. However, it underestimates the total amount of nitrogen in manure because it does not measure the organic nitrogen fraction.

Ammonium quick testers are most useful when used for frequent manure testing such as before each manure application on grass.

Table 1. Equations for converting manure analysis results into units of kg/tonne (wet basis).

Conversion Equations		Conversion Examples	
Conversion	**Equation**	**Sample Manure Data**	**Sample Calculation**
lb/ton (wet basis) to kg/tonne (wet basis)	lb/ton x 0.5 = kg/tonne	Nitrogen = 5 lbs/ton	5 lbs/ton x 0.5 = 2.5 kg/tonne N
% (wet basis) to kg/tonne (wet basis)	% x 10 = kg/tonne	Nitrogen = 0.5%	0.5% x 10 = 5 kg/tonne N
mg/kg (wet basis) to kg/tonne (wet basis)	mg/kg ÷1000 = kg/tonne	Nitrogen = 5000 mg/kg	5000 ÷ 1000 = 5.0 kg/tonne N
%(dry basis) to kg/tonne (wet basis)	[(% nutrient) ÷ (% dry matter*)] x 10 = kg/tonne	Nitrogen = 2.8 % (dry matter basis) Dry matter = 6.2%	[2.8 ÷ 6.2] x 10 = [0.45] x 10 = 4.5 kg/tonne N
ppm (dry basis) to kg/tonne (wet basis)	ppm nutrient ÷ 10,000 = % nutrient (% nutrient ÷ % dry matter) x 10 = kg/tonne	Ammonium-Nitrogen (NH_4-N) = 10,300 ppm Dry matter = 6%	10,300 ÷ 10,000 = 1.03 % NH_4-N [1.03 ÷ 6] x 10 = [0.17] x 10 = 1.7 kg/tonne NH_4-N

Notes

- dry matter, DM, total solids and TS are equivalent terms
- if dry matter value is not given, assume 8.5% for dairy manure, 1.9% for pig manure
- ppm, µg/g, µg/mL, mg/kg and mg/L are approximately equivalent units for manure nutrients

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Phosphorus Considerations for Nutrient Management

Nutrient Management Factsheet – No. 6 in Series

Revised September 2010 – Order Reference No. 631.500-4

Soils that have an elevated phosphorus (P) concentration can pose a risk to surface water sources. This factsheet gives agricultural management guidelines to minimize the risk of phosphorus pollution of sensitive receiving environments.

Movement of soil P into freshwater lakes or streams can speed up eutrophication, associated with algal blooms followed by depletions in the water's oxygen supply caused by the algae's death and decomposition. Eutrophication has led to fish kills and restrictions of water use for recreation, drinking and industry.

In general terms, soil P can be transported into waters in sediment-bound or dissolved forms. Sediment-bound P includes eroded soil and organic matter particles, which may not cause eutrophication immediately but is a long-term source of P in aquatic systems. Most dissolved P in runoff is immediately available to cause eutrophication.

Identifying Sensitive Receiving Environments

High phosphorus soils are a concern in the following circumstances:

- Where streams and drainage systems empty into lakes
- Where there is opportunity for soil P transport from the fields to surface waters
- Where fields have subsurface drainage systems that empty ultimately into a lake system

Areas likely to have P-sensitive surface waters include but are not limited to the Okanagan Basin, Christina Lake Basin, Thompson River system from Savana and areas in Schedule 5 of the *Municipal Sewage Regulation.*

In areas of BC where fresh water and subsurface drainage systems drain into major rivers that enter salt water, high phosphorus soils are not a major concern at this time.

In phosphorus-sensitive areas of BC, fields that are located well away from freshwater and where there is no risk of P transport into freshwaters, high phosphorus soils are not considered a major concern at this time.

Management Practices to Minimize Phosphorus Loss by Erosion and Runoff

In sensitive receiving environments, the following management practices are recommended:

- Do not apply manure or fertilizer when there is risk of surface runoff from rain or snowmelt into the stream
- Establish well-vegetated buffer strips between the stream and field to catch eroded material
- Do not apply manure or fertilizer in the buffer strips
- Avoid over-applying P in manure and fertilizer to keep soil concentrations in the optimum range (**Table 1**), since phosphorus concentrations in runoff (surface and subsurface) increase with soil P concentration
- Improve irrigation and drainage management to minimize erosion and runoff
- Plant cover crops where practical to reduce erosion in fields with high soil P
- Direct surface runoff to retention/settling ponds

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Phosphorus Loss through the Subsurface

Phosphorus can also move downward through the soil into drainage systems, and enter surface water through this route.

The main route of phosphorus movement downward through the soil is by preferential flow which is the rapid movement of soil water (and liquid manure) through cracks, fissures and biological macropores (worm borings) in the soil directly to drain tiles or groundwater.

Although P-binding capacities of soils are generally high, soils have limits to their P-binding capacities and these capacities vary with soil properties. In soils with high or excess phosphorus concentrations that exceed the soil's P binding ability, some phosphorus can leach and enter surface waters by subsurface flow.

Management Practices to Minimize Phosphorus Loss from Drainage Systems

The following practices will help minimize the risk of phosphorus loss through subsurface-drainage systems:

- Tile-drained fields in sensitive areas should be tilled before manure or fertilizer application in the spring to break up cracks and macropores.
- On fields in perennial forage where pre-application tillage can only be done with slurry application tillage implements like "Aerway", you can also limit phosphorus loss in drain tiles by applying liquid manure in several small applications throughout the growing season.

Management Practices for Reducing Phosphorus Concentrations

Soil testing is an important part of managing fields and crops to avoid phosphorus buildup. **Table 1** provides general agronomic soil test ratings to assist planners and farmers in developing a strategy for P management.

Soil test P methods were evaluated for some BC soils in recent years for environmental purposes. Results suggested that in the Lower Fraser Valley, agronomic soil P ratings (similar to the ratings in **Table 1**) could be used for assessing risk of P loss from soils due to water[1]. If receiving waters are not sensitive to P loading, however, the risk of P pollution is minimized. In general, P is bound more than two times as tightly in Fraser Valley soils in comparison to Okanagan soils[2]. This alone suggests that environmental soil P limits for the Okanagan should be lower than those in Table 1; however, naturally low precipitation in the Okanagan reduces the overall risk of soil P *transport* into surface waters[2]. Although a single set of soil P limits may not be appropriate for all soils and requires careful interpretation for environmental purposes, agronomic soil P ratings like those in Table 1 should be considered a first step in a comprehensive management plan for phosphorus.

Table 1. Target indices for soil test phosphorus (P) for mineral soils in BC (0-15 cm sample depth).

Soil test P*	Management Strategy
< 40 ppm	**Low to Medium**– crops may respond beneficially to additional P
41 – 75 ppm	**Medium to Optimum** – aim to maintain levels in this range
76 – 100 ppm	**High** – aim to reduce soil P levels; additional P (except as starter P) is likely to have minimal benefit to crops
> 100 ppm	**Excess** – aim to reduce soil P levels; additional P (except as starter P) is not likely to benefit crops for at least 2 years

*Values are provided for the Kelowna extraction method. To compare with results of other methods, see Factsheet 3 of the Nutrient Management Factsheet Series.

Fields with low to medium levels of soil P: Manure can be applied at rates to meet the entire crop P requirement as long as it does not exceed crop nitrogen requirements.

Fields with optimum levels of soil P: These fields have enough P to meet the requirements of most crops this cropping year.

If soil P approaches high levels, decrease the average annual application rate of manure to account for crop-available P from manure applications in the current and previous years. This might be done by applying manure one year and none the next – an alternative to reducing application rates by half each year. Assume 50% of the manure P is crop-available in the year of application to ensure sufficient P is applied; most of the remaining P will build up soil P and become crop-available in the following years.

Fields with high or excess levels of soil P: Even with high or excess soil P levels, some annual crops like corn may respond favourably to about 25 kg/ha (22 lbs/ac) phosphate fertilizer (P_2O_5) as a starter fertilizer. At high soil P levels, crops have enough 'money (P) in the bank (soil)' to do well without other additions of phosphorus.

It is recommended that fields in sensitive areas with high or excess soil P levels receive no manure or fertilizer phosphorus until soil levels decline. Manure should be applied instead to fields that are low in phosphorus or less vulnerable to soil P transport.

If manure must be applied to high phosphorus fields, ensure that the fields that receive the most manure are located at the greatest distance from surface water or ditches. In these fields, more than 50% of the total manure P is crop available in the year of application and this percentage increases up to as much as 100% at very high soil P levels.

Long Term Strategies

If all the fields on a farm have high phosphorus levels and are at risk for P transport into sensitive waters, management becomes more difficult. Because all excess phosphorus remains in the soil for future crops to use, it will become increasingly important to have strategies that allow farmers to minimize manure applications to high phosphorus soils.

As manure application rates are decreased (to reduce soil P loading), it will be more important to ensure crop nitrogen (N) requirements are still met.

- Increase attention to conserving more manure nitrogen by using equipment and practices that decrease ammonia emissions from spreading[3].
- Using mineral fertilizer to satisfy part of the crop N requirements has benefits: a more predictable supply of nitrogen and often better uniformity of application compared to manure.
- Alternatively, legumes can effectively replace significant amounts of N fertilizer by 'fixing' nitrogen from the air. Incorporate legumes into the crop rotation if possible.

Work with nutritionists to fine-tune animal diets or feeding strategies to reduce P imports onto the farm in feed or to balance rations to allow animals to use more P from feed so that less P is excreted in manure.

Seek arrangements over the next few years to export manure phosphorus off the farm. Developments in technologies may emerge to make this more feasible. These developments could include composting to allow for easier transport, better solid-liquid manure separation, struvite extraction of phosphorus from manure, or gasification of manures producing ash and energy. Globally, there is a growing demand for phosphorus fertilizer, so excess manure P will be increasingly valuable if it can be transported to those markets.

References

1. Kowalenko, C.G., Schmidt, O. and Hughes-Games, G.A. 2007. Fraser Valley soil nutrient study 2005. A survey of the nitrogen, phosphorus and potassium contents of the Lower Fraser Valley agricultural soils in relation to environmental and agronomic concerns. http://www.agf.gov.bc.ca/resmgmt/EnviroFarmPlanning/FV_SoilNutrientStudy/_FVSNS-CombinedReport_Feb28_2007_for_Release.pdf.

2. Kowalenko, C.G., Schmidt, O., Kenney, E., Neilsen, D. and Poon, D. 2009. Okanagan agricultural soil study 2007. A survey of the chemical and physical properties of agricultural soils of the Okanagan and Similkameen Valleys in relation to agronomic and environmental concerns. http://www.agf.gov.bc.ca/resmgmt/EnviroFarmPlanning/OK_AgricSoilStudy2007/Okanagan_Soil_Study_Report_2007.pdf.

3. For an interactive demonstration of how environmental conditions and equipment can reduce nitrogen (ammonia) emissions from liquid manure spreading, see the Ammonia Loss from Applied Slurry Manure tool online at http://www.farmwest.com/index.cfm?method=climateammonia.showgraph

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Potassium Considerations for Nutrient Management

Nutrient Management Factsheet – No. 7 in Series

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High potassium forages are becoming increasingly of concern in intensively farmed areas of the province. Potassium is not considered to be a nutrient of environmental (water quality) concern. However, when potassium uptake in forages exceeds acceptable concentrations, there can be a significant impact on cattle health.

Primary Causes of Elevated Potassium in Forages

Soil test potassium levels become elevated when potassium is applied in manure or fertilizer over the long term at rates well above crop requirements.

The primary cause is over-application of potassium in manure. Farmers applying manure at rates targeted to meet the nitrogen requirements of a crop will generally be applying potassium in excess. In one long-term manure application study, soil potassium levels in manured treatments increased by 35% in only 3 years.

When soil potassium concentrations become elevated, forage grasses and alfalfa will take up this potassium in direct proportion to its concentration in the soil, far beyond the amount required for normal growth of the crop. This process is often referred to as 'luxury consumption.' The result is forages with potassium levels much higher than normal.

Impacts on Cattle Health from High Potassium Forages

When potassium concentrations in the diet exceed 3.5%, the potassium interferes with the uptake of calcium and magnesium in the cow's digestive tract. The cow is not able to keep these nutrients at the desired level in her body as there is so much competing potassium. This imbalance of calcium and magnesium can lead to many health problems in dairy cows including milk fever, calving problems and displaced abomasums. Dry cows are particularly sensitive to high potassium concentrations in forage.

A high potassium diet will also result in increased water consumption by affected cows, and increased urine output which puts stress on the kidneys. This in turn can have long-term implications for the health of the cow.

Challenges of Breaking the High Potassium Cycle

High soil potassium is often an indicator of farms that do not have an adequate land base for the amount of manure generated. These farms are often unable to produce enough home-grown feed and depend more on imported feeds that bring even more potassium onto the farm.

High potassium soils create a difficult to break cycle on a farm. Most of the potassium consumed by the cow in her ration is excreted in the urine and is re-captured in the manure. The manure is reapplied to the field, where forages take it up in 'luxury' levels again.

Very little potassium is lost during the storage and application of manure, and most soils have the capacity to hold large amounts of potassium. Once the soil level of potassium is elevated, the excess potassium is difficult to get rid of unless forage is sold off farm and low potassium forage is purchased and brought on farm.

Management Practices for Reducing Potassium Concentrations

Soil

Soil testing is an important component of managing fields and crops to avoid potassium buildup. Table 1 provides general guidance to assist planners and farmers in developing a strategy for potassium management.

- If soil potassium levels are high or excessive, monitor the levels annually on the entire farm.
- If manure must be applied, calibrate application rates so that potassium application is equivalent to or less than crop requirement.
- If manure must be applied, favour fields with low soil potassium to receive higher rates of potassium.
- Stop any applications of potassium in commercial fertilizer or from off-farm manure sources.
- If soil test potassium level exceeds 320 ppm (Kelowna method; see Table 1), avoid manure application for one year and continue monitoring soil potassium levels.

Forage

- Set aside a specific field for feeding dry cows. Do not manure this field, and use no potassium fertilizer. If fertilized with nitrogen, the soil potassium level will likely decline to a safe level within a year or two.
- Dilute high potassium forages with low potassium feeds. If necessary, purchase forages from non-livestock operations where soil potassium levels should be lower.
- Develop a strategy to increase home-grown feed in the ration. Consider growing and harvesting winter cover crops or relay crops on corn land. If necessary, purchase or rent additional land.
- Harvest later if possible. Potassium levels in forage decrease with advanced maturity.

Table 1. Target indices for soil test potassium (K) for mineral soils in BC (0-15 cm sample depth). Soil test potassium extraction methods are provided in brackets.

Soil K (Kelowna)	Soil K (Mehlich 3)	Soil K (Ammonium Acetate)	Soil K (Modified Kelowna-95*)	Management Strategy
< 100 ppm	<133 ppm	<125 ppm	<131 ppm	**Low** – crop is likely to respond beneficially to additional potassium
100-250 ppm	133-333 ppm	125-312 ppm	131-329 ppm	**Optimal** – aim to maintain levels in this range
251-320 ppm	334-426 ppm	313-400 ppm	330-421 ppm	**High** – aim to reduce levels; try to avoid potassium applications (as manure or fertilizer) for one year
>320 ppm	> 426 ppm	>400 ppm	>421 ppm	**Excess** – aim to reduce levels; potassium applications can be avoided for two years

*Modified Kelowna method developed by Ashworth and Mrazek (1995)

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Choosing and Calibrating Manure Application Equipment

Nutrient Management Factsheet – No. 8 in Series

Revised September 2010 – Order Reference No. 631.500-6

If manure is being used as a primary nutrient source for crop production, choosing the right manure application equipment and properly calibrating that equipment is a key component of optimizing nutrient use. This factsheet provides guidance on both of these processes.

Tables 1 and 2 describe the advantages and disadvantages of the major kinds of manure application equipment currently being used.

Table 1. Solid manure application methods by order of decreasing preference.

Method	Advantages	Disadvantages
Spinning Disks	• easy calibration • accurate placement • fast application	• need dry manure • high dust production
Flail Broadcast	• can spread variable moisture content	• inaccurate placement • non-uniform application
Dump and Grade Not recommended for use due to poor uniformity	• low cost	• cannot be calibrated • non-uniform application • difficult to control rate

Desirable Traits in Application Equipment

Overall, the most desired methods are those that apply manure as uniformly as possible, have low emissions and spray drift, and are cost effective. Methods that have accurate placement on the soil surface or within the crop canopy require less buffer distance to sensitive areas.

Incorporating manure, solid or liquid, soon (i.e. within 2 hours) after application will significantly reduce odour and nitrogen losses into the air.

Damage to crops will be reduced by methods that use high floatation tires, place manure under the canopy, deliver dilute slurry or have low soil disturbance.

Methods that reduce the risk of preferential flow of manure or nutrients to drains include using solid manure or tilling before or after application of liquid manure.

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Table 2. Liquid manure application methods by order of decreasing preference.

Method	Advantages	Disadvantages
Sleighfoot or Aerator with Dribble Bar (attached to vacuum tanker)	• easy calibration • uniform application • accurate placement • low ammonia loss • fertilizer value maximization • wider spreading window • minimal nitrous oxide (N_2O) release	• higher cost • slow application • crop damage from wheels if applied when crop is tall • soil compaction from tanker
Low Trajectory Boom (attached to hose reel or vacuum tanker)	• low soil compaction • low crop damage • low N_2O release	• higher risk of run-off • shorter application window • soil compaction (with a tanker) • slow application (with a tanker)
Injector (attached to hose reel or vacuum tanker)	• easy calibration • uniform application • accurate placement • fertilizer value maximization • ammonia and odour reduction • fast application (with hose reel)	• potentially high N_2O release, particularly when soils become saturated after application • only suitable for some soil and crop conditions and short application window • higher cost • low application rate difficult to achieve • soil compaction (with tanker) • slow application (with tanker)
Splash Plate (on vacuum tanker)	• easy calibration • lower cost • low nitrous oxide release	• soil and crop compaction • short application window • high ammonia loss • non-uniform application
Irrigation Gun (attached to hose reel) Not recommended for use due to odour, calibration, uniformity and placement problems	• low cost • rapid application rate • low N_2O release	• difficult to calibrate • non-uniform application • inaccurate placement • high risk of runoff • short application window • high ammonia loss • high risk of pathogen, aerosol and odour drift

Calibrating Application Equipment

Calibration techniques are used to determine the amount of solid or liquid applied per unit area or unit of time for a specific manure applicator.

Calibration is also used to evaluate the uniformity of application. Applying manure uniformly has increased forage crop yield increases up to 15% compared to non-uniform applications.

Figure 1 shows a graphical representation of ideal uniformity over the width of a manure application pattern (splash plate, gun or solid spreader). Note that effective width is less than the spreader width. However, the correct overlapping of runs can result in a uniform application over the field.

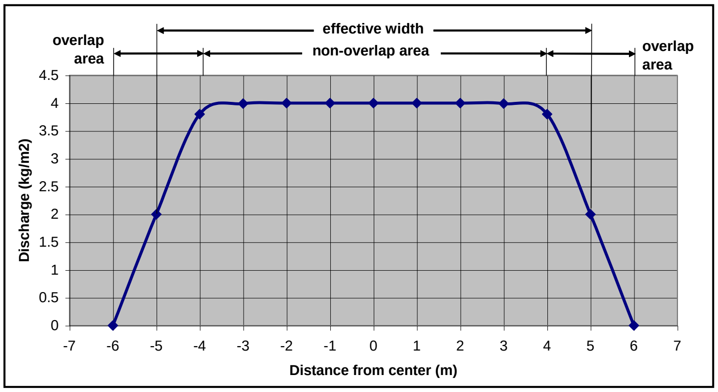

Figure 1. An ideal manure distribution pattern

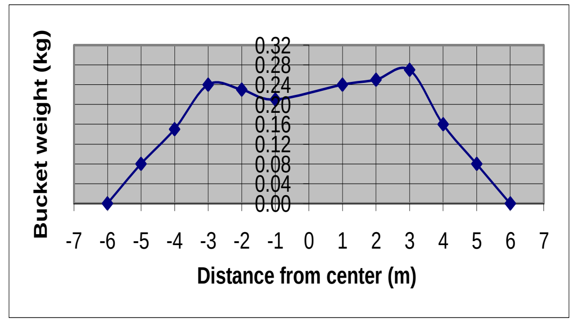

Figure 2. Uniformity of an Actual Manure Application

Assessing Application Uniformity

1. Place a number of containers (of uniform size and shape) in a line perpendicular to the path the spreader will travel. If possible, use 10 or more containers in order to see how the uniformity changes over the spreader width. Measure the distance the containers are from the centre line of the proposed spreader path.
2. Apply manure, starting far enough back form the row of containers so that the spreader is operating at the desired working speed when it passes the containers.
3. Record the weight of manure in each container (see **Example 1** and **Table 3**), and plot the results **(Figure 2)**.

Table 3. Example of Bucket Sample Weights for Manure Application Uniformity Test.

Bucket number	Distance from centre (m)	Amount of manure collected (kg)
1	+6	0.0
2	+5	0.08
3	+4	0.16
4	+3	0.27
5	+2	0.25
6	+1	0.24
7	-1	0.21
8	-2	0.23
9	-3	0.24
10	-4	0.15
11	-5	0.08
12	-6	0.0

4. Using the container weights from the non-overlap area (**Figure 1**), calculate the deviation in weights from the average (see **Example 1** and **Table 4**). If the weight of manure in any container from the non-overlap area is more than 15% above or below the average, adjust the spreader (splash plate angle, beater bars etc.) to improve uniformity and repeat the previous steps.

Table 4. Calculation of deviation from average manure application rate (average = 0.24 kg in this example).

Bucket number	Amount of manure collected (kg)	Percent difference (%)
4	0.27	0.27 / 0.24 = 113%
5	0.25	0.25 / 0.24 = 104%
6	0.24	0.24 / 0.24 = 100%
7	0.21	0.21 / 0.24 = 88%
8	0.23	0.23 / 0.24 = 96%
9	0.24	0.24 / 0.24 = 100%

Example 1: Assessing Uniformity

A manure applicator calibration test was done following the steps above. Bucket weights are shown in **Table 3**. The results were plotted on a graph (**Figure 2**).

From the graph, the non-overlap area was determined to be between -3 m to +3 m or buckets 4 to 9.

Calculating the average weight of manure in buckets 4 to 9 gives 0.24 kg. The calculation showing deviation from the average for buckets 4 to 9 is shown in **Table 4**. This is acceptable uniformity since all buckets in the non-overlap area are within 15% of the average.

As manure nutrients become available over time, varying the application pattern will tend to average out any minor uniformity problems – see **Figure 3** for an example.

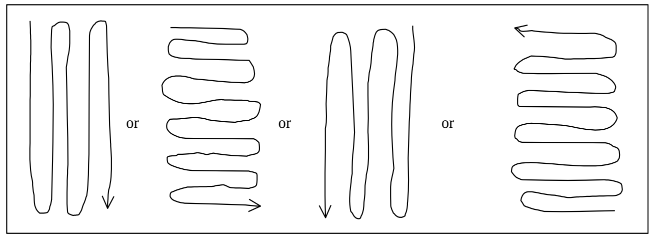

Figure 3. Ways to vary manure application patterns.

Determining Tractor Speed for Target Manure Application Rate

Once a satisfactory uniformity has been achieved, then calibrate by following these steps to obtain the desired loads per hectare:

1. Determine the effective width (m) from the graphical representation (**Figure 1**) of the uniformity test. The effective width is when the overlap area is at half the average of the non-overlap area. In Example 1 half the average is 0.12 kg, and this occurs at -4.5 m and +4.5 m, therefore the effective width is 9.0 m.
2. Fill the spreader with manure and spread the load, recording the speed driven (km/h) and measure the length covered (m).
3. Determine the area covered in hectares (ha) by multiplying the length covered by the effective width and dividing by 10,000.
4. Determine the correct speed (km/h) to drive to achieve a desired application rate by dividing the speed used in the test (km/h) by the product of multiplying area covered (ha) by desired rate (tankers/ha).

   Speed (km/h) = speed used in test (km/h) / [area covered (ha) x desired rate (tankers/ha)]

Example 2: Determining Tractor Speed to Achieve Desired Loads per Hectare

A 9.4 m^3 manure spreader covers 357 m length when driving at 3.0 km/h.

Effective width from **Example 1** is 9.0 m.

The area covered in the calibration test was,
9.0 m x 357 m = 3200 m^2 or 0.32 ha

The calculation for desired speed is shown in Table 5.

If the calculated speed is too fast for your equipment apply at half the speed and space the centre line of each application at twice the distance apart.

Table 5. Calculation of tractor speed to achieve desired loads per hectare (3.0 km/h speed and 0.32 ha used in test).

Desired application rates (tankers/ha)	Speed required (km/h)
5 ½	3.0 ÷ (0.32 x 5 ½) = 3.0 ÷ 1.77 = **1.7**
5 ¼	3.0 ÷ (0.32 x 5 ¼) = 3.0 ÷ 1.69 = **1.8**
4	3.0 ÷ (0.32 x 4) = 3.0 ÷ 1.29 = **2.3**
3 ¾	3.0 ÷ (0.32 x 3 ¾) = 3.0 ÷ 1.20 = **2.5**
3 ¼	3.0 ÷ (0.32 x 3 ¼) = 3.0 ÷ 1.04 = **2.9**
2 ¼	3.0 ÷ (0.32 x 2 ¼) = 3.0 ÷ 0.72 = **4.1**
1 ¼	3.0 ÷ (0.32 x 1 ¼) = 3.0 ÷ 0.40 = **7.5**

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