APPENDIX F

Soil Sampling Programs

Soil sampling for laboratory analysis is the only way to determine the levels of plant nutrients in a field and obtain fertilizer recommendations for that field. It is also required to determine whether nutrients have accumulated deep in the soil profile. A proper soil sampling program for sustainable manure management follows sound principles and includes every field, every year. Fall sampling should be done when soil temperatures are low (ideally <5°C) so that nutrient concentrations are not likely to change after testing. Spring sampling should be done as early as possible so results are not affected by warming of the soil. There are several aspects to a comprehensive soil sampling program, and a number of sampling strategies that can be used, depending on field conditions, cost and management objectives.

I. Annual Soil Sampling

The most common type of sampling program is annual soil sampling. Manure application fields should be sampled annually to determine residual nutrient levels for both agronomic and environmental purposes. Continually elevated nitrate or phosphorus levels detected during annual sampling may indicate an increased risk of nitrate leaching below the root zone (predominantly the upper 60 cm or 2 ft) or phosphorus loss via runoff or erosion.

Sampling Procedure:

- Follow the general instructions contained here or, preferably, consult the appropriate publications from Manitoba Agriculture, Food and Rural Initiatives for more detailed explanations of the various sampling strategies:
- Tri-Provincial Manure Application and Use Guidelines
- Manitoba Soil Fertility Guide
- Soil Sampling Strategies for Site Specific Management factsheet
- Sample annually in late fall or just prior to manure application. Note: the turnaround time for soil test results is typically longer during peak periods (allow one to two weeks if possible).
- Sample one location every three to four hectares (ha) (seven to ten acres (ac)). A minimum of 15 to 20 sample locations per field is recommended.
- Follow standard recommended soil testing procedures for obtaining and handling samples.
- Form one composite sample for each of the 0 to 15 cm (0 to 6 in) depth and 15 to 60 cm (6 to 24 inch) depth.
- At a minimum, have the 0 to 15 cm (0 to 6 in) sample analyzed for nitrate-nitrogen and phosphorus. The remaining samples should be analyzed for nitrate-nitrogen.

Interpreting the Results:
If any of the following criteria are met, consult a qualified professional to obtain sound recommendations for cropping and fertilization practices. Manure application to soils with nitrate-N levels above the regulatory limits is not recommended.

- Nitrate-nitrogen levels in the 0 to 60 cm (2 ft) depth must not exceed the maximum permitted concentrations specified in the Livestock Manure and Mortalities Management Regulation (see Appendix B).
- If the concentration of soil test phosphorus is less than 60 parts per million (ppm) P (based on the Olsen method) in the 0 to 15 cm (0 to 6 in) depth, manure may be applied based on N, however, efforts should be made to minimize P loading to soil (e.g. N conservation during storage or application).
- If the concentration of soil test phosphorus is 60 to 119 ppm P (Olsen) in the 0 to 15 cm (0 to 6 in) depth, manure should be applied at a rate no greater than two times the crop removal rate for P_2O_5.
- If the concentration of soil test phosphorus is 120 to 179 ppm P (Olsen) in the 0 to 15 cm (0 to 6 in) depth, manure should be applied at a rate no greater than one times the crop removal rate for P_2O_5.
- If the concentration of soil test phosphorus is 180 ppm P (Olsen) or greater in the 0 to 15 cm (0 to 6 in) depth, manure application should be discontinued.

The latter criteria for phosphorus are based on recommendations found in the Final Report of the Manitoba Phosphorus Expert Committee (2006).

Maximum Allowable Nitrate-nitrogen In The Top 60 Cm (2 Ft) Of Soil Under The Livestock Manure And Mortalities Management Regulation.[1]

Agriculture Capability Rating	Maximum Residual[2] Nitrate-Nitrogen	
	(kg/ha)	(lb/ac)
Class 1, 2 and 3 (except 3M and 3MW)	157.1	140
Class 3M, 3MW and 4	101	90
Class 5	33.6	30
Class 6, 7 and unimproved organic soils	N/A	N/A

[1] Consult the Livestock Manure and Mortalities Management Regulation for details on the nitrate limits, including exemptions.

[2] Refers to nutrient remaining in soil after the production of a crop.

II. Initial Shallow and Deep Sampling

Initial shallow and deep sampling of benchmark sites is recommended for fields about which little is known regarding past fertilization practices or fields suspected of having received heavy or repeated fertilizer applications. The objective is to establish current soil nutrient levels, near and well below the surface before beginning or continuing manure application. Crop selection and manure application rates can then be tailored according to existing, site-specific conditions (e.g. accumulation of phosphorus near the surface or nitrate-nitrogen deep in the soil).

Sampling procedure:

- Follow the general instructions contained here or, preferably, consult the appropriate publications from Manitoba Agriculture, Food and Rural Initiatives for more detailed explanations of the various sampling strategies:
- Tri-Provincial Manure Application and Use Guidelines
- Manitoba Soil Fertility Guide
- Soil Sampling Strategies for Site Specific Management factsheet
- Sample an appropriate number of benchmark sites (minimum three to five depending on field size and expected variability) that represent the field as a whole. Results for these sites can be used as a baseline for periodic soil nutrient monitoring (see Section III of this appendix). At each benchmark site, a minimum of 15 to 20 randomly selected sample locations is required.
- Each location should be sampled to a depth of 3.6 m (12 ft).
- Follow standard recommended soil testing procedures for obtaining and handling samples.
- Form one composite sample for the 0 to 15 cm (0 to 6 in) depth, 15 to 60 cm (6 to 24 in) depth and for each 30 cm (1 ft) increment thereafter by combining soil from all locations.
- At a minimum, have the 0 to 15 cm (0 to 6 in) sample analyzed for nitrate-nitrogen and phosphorus. The remaining samples should be analyzed for nitrate-nitrogen.

Interpreting the Results:

If any of the following criteria are met, consult a qualified professional to obtain sound recommendations for cropping and fertilization practices. Deep rooted perennial crops, such as alfalfa, can be grown to recover nitrates that have leached deeply into the soil profile. Growing crops with relatively high capacities for P removal may also need to be considered. In any case, manure application may need to be done at reduced rates or avoided until nutrient levels decline to reduce agronomic and environmental risk.

- Nitrate-nitrogen that has accumulated between 0 and 1.2 m (4 ft) below the surface should not exceed 160 kg/ha (140 lb/ac).
- Nitrate-nitrogen that has accumulated between 1.2 and 3.6 m (4 and 12 ft) below the surface should not exceed 22 kg/ha (20 lb/ac) in each 30 cm (1 ft) increment.
- If the concentration of soil test phosphorus is less than 60 ppm P (based on the Olsen method) in the 0 to 15 cm (0 to 6 in) depth, manure may be applied based on N, however, efforts should be made to minimize P loading to soil (e.g. N conservation during storage or application).

- If the concentration of soil test phosphorus is 60 to 119 ppm P (Olsen) in the 0 to 15 cm (0 to 6 in) depth, manure should be applied at a rate no greater than two times the crop removal rate for P_2O_5.
- If the concentration of soil test phosphorus is 120 to 179 ppm P (Olsen) in the 0 to 15 cm (0 to 6 in) depth, manure should be applied at a rate no greater than one times the crop removal rate for P_2O_5.
- If the concentration of soil test phosphorus is 180 ppm P (Olsen) or greater in the 0 to 15 cm (0 to 6 in) depth, manure application should be discontinued.

The latter criteria for phosphorus are based on recommendations found in the Final Report of the Manitoba Phosphorus Expert Committee (2006).

III. Periodic Monitoring

Periodically, intensive shallow and deep sampling, using benchmark sites can be done to better monitor for nitrate and phosphorus accumulation, especially in areas near surface water or situated over aquifers that have limited protection from overlying materials.

Sampling Procedure:

- Follow the general instructions contained here or, preferably, consult the appropriate publications from Manitoba Agriculture, Food and Rural Initiatives for more detailed explanations of the various sampling strategies:
- Tri-Provincial Manure Application and Use Guidelines
- Manitoba Soil Fertility Guide
- Soil Sampling Strategies for Site Specific Management factsheet
- Sample an appropriate number of benchmark sites (minimum three to five depending on field size and expected variability) that represent the field as a whole. If initial shallow and deep sampling (Section I of this appendix) were conducted, these benchmark sites should ideally match those selected previously. At each benchmark site, a minimum of 15 to 20 randomly selected sample locations is required.
- Follow standard recommended soil testing procedures for obtaining and handling samples.
- Form one composite sample for the 0 to 15 cm (0 to 6 in) depth, 15 to 60 cm (6 to 24 in) depth and for each 30 cm (1 ft) increment thereafter to 1.2 m (4 ft) by combining soil from all locations.
- At a minimum, have the 0 to 15 cm (0 to 6 in) sample analyzed for nitrate-nitrogen and phosphorus. The remaining samples should be analyzed for nitrate-nitrogen.

Interpreting the Results:

If any of the following criteria are met, consult a qualified professional to obtain sound recommendations for cropping and fertilization practices. Deep rooted perennial crops, such as alfalfa, can be grown to recover nitrates that have leached deeply into the soil profile. Growing crops with relatively high capacities for P removal may also need to be considered. In any case, manure application may need to be done at reduced rates or avoided until nutrient levels decline to reduce agronomic and environmental risk.

- The total nitrates in the 0 to 1.2 m (0 to 4 ft) depth should not exceed 160 kg/ha (140 lb/ac).

- If the concentration of soil test phosphorus is less than 60 ppm P (based on the Olsen method) in the 0 to 15 cm (0 to 6 in) depth, manure may be applied based on N, however, efforts should be made to minimize P loading to soil (e.g. N conservation during storage or application).

- If the concentration of soil test phosphorus is 60 to 119 ppm P (Olsen) in the 0 to 15 cm (0 to 6 in) depth, manure should be applied at a rate no greater than two times the crop removal rate for P_2O_5.

- If the concentration of soil test phosphorus is 120 to 179 ppm P (Olsen) in the 0 to 15 cm (0 to 6 in) depth, manure should be applied at a rate no greater than one times the crop removal rate for P_2O_5.

- If the concentration of soil test phosphorus is 180 ppm P (Olsen) or greater in the 0 to 15 cm (0 to 6 in) depth, manure application should be discontinued.

The latter criteria for phosphorus are based on recommendations found in the Final Report of the Manitoba Phosphorus Expert Committee (2006)

Soil Sampling Procedure
Reliable results can only be obtained if the samples are fully representative of the field or area from which they are taken. Proper sampling and sample handling procedures must also be followed.

Selecting Areas to Sample
Soil sampling is normally done on an individual field basis with a single composite sample representing the whole field. Individual fields that are not uniform should be divided into smaller sampling units with a single composite sample representing each unit. The soil in each of these sampling units should have similar properties, such as colour, texture, cropping history, and fertilizer or manure treatments. One way to separate sampling units is by limitation, such as droughtiness, slope, salinity, stoniness or excess moisture. Any area that is different in these features and which is large enough to have manure applied at a different rate should be sampled separately.

All abnormal areas such as old manure piles, burn piles, haystacks, corrals, fence rows or farmstead sites should also be avoided, as well as locations of past synthetic fertilizer spills. Samples should not be taken along headlands, within 15 m (50 ft) of field borders or shelterbelts, or within 45 m (150 ft) of built up roads.

If the field has been cultivated, take the sample from the compacted soil in wheel tracks.

Equipment and Supplies
Special augers or probes designed for soil sampling must be used. These may be hand or hydraulic powered. Independent service providers may also be available to custom sample fields. Use clean, labeled plastic pails for collecting samples. Information sheets, sample containers and shipping boxes are usually available from the lab conducting the analysis.

Mechanical and hydraulic samplers may yield poor samples on very dry or wet soils. In all cases avoid getting topsoil in the subsoil samples, or subsoil in the topsoil samples. For example, in very dry soils, be careful not to let topsoil spill into the hole before taking deeper samples.

Handling Samples
Take care to keep samples clean and uncontaminated. If possible, send samples to the laboratory immediately. If this is not possible, or if a delay of more than 48 hours is anticipated, freeze or dry the samples. Follow these steps to dry samples:

- Mix the soil in each container thoroughly breaking lumps so they are less than 12 mm (0.5 in) in diameter.
- Remove about 0.5 L (1 pint) of soil and spread on a piece of clean paper.
- Completely dry at a temperature of not more than 30oC. Do not dry in an oven at a high temperature, since this can change the phosphorus, potassium and sulphur levels.
- Avoid contamination of the samples with foreign materials such as commercial fertilizer, manure, salt, baking soda, water, dust, etc. Samples should not be dried on old fertilizer or feed bags, or in areas where fertilizers have been handled.
- A fan may be used to ensure constant air flow over samples and enhance drying.

Once the sample is thoroughly dry, fill the soil sample bags provided by the lab. Label each bag with the correct field identification and sample depth. Complete an information sheet for each field.

Keeping Records
It is wise to maintain long-term detailed records on fields sampled. The records should include:

- fertilizer and manure application rates
- previous soil test results
- soil condition at sampling (temperature, moisture, crop cover, etc.)
- a map of where the soil samples were taken in each field (preferably geo-referenced using GPS)
- production information

These records may be needed to explain variations in annual test results, track trends in soil nutrient levels and enable refining of manure application recommendations.

Summary
Properly designed and conducted soil sampling programs reduce risk to surface and groundwater from the application of commercial fertilizer or manure. Producers should learn the fundamentals of soil sample collection and handling regardless of whether they do their own soil sampling or contract the work to service providers. Information obtained from an intensive soil sampling program is of considerable value to crop production for both agronomic and environmental reasons.

Soil Sampling Summary Table

A. Metric	Number of Locations[1]	Sampling Depth	Number of Samples	Maximum Nitrate-Nitrogen that should be found
I Annual Monitoring	1 per 3 to 4 ha	0.6 m	One composite sample, 0 to 15 cm One composite sample, 15 to 60 cm	See section 13, Appendix B
II Initial Shallow and Deep Monitoring	3 to 5 benchmark sites	3.6 m	One composite sample, 0 to 15 cm One composite sample, 15 to 60 cm One composite sample, every 30 cm thereafter	0 to 1.2 m - 160 kg/ha 1.2 to 3.6 m - 22 kg/ha per 30 cm
III Periodic Monitoring	3 to 5 benchmark sites	1.2 m	One composite sample, 0 to 15 cm One composite sample, 15 to 60 cm One composite sample, every 30 cm thereafter	160 kg/ha
B. Imperial				
I Annual Monitoring	1 per 7 to 10 ac	2 ft	One composite sample, 0 to 6 in One composite sample, 6 to 24 in	See section 13, Appendix B
II Initial Shallow and Deep Monitoring	3 to 5 benchmark sites	12 ft	One composite sample, 0 to 6 in One composite sample, 6 to 24 in One composite sample, every 12 in thereafter	0 to 4 ft -140 lb/ac 4 to 12 ft - 20 lb/ac per ft
III Periodic Monitoring	3 to 5 benchmark sites	4 ft	One composite sample, 0 to 6 in One composite sample, 6 to 24 in One composite sample, every 12 in thereafter	140 lb/ac

[1] In all situations a minimum of 15 sample locations are recommended.