

Research in Support of the Manitoba Clean Environment Commission's Hog Production Industry Review

Task 1 – Analysis Framework for Total Nutrient Loading

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1 Introduction

Lake Winnipeg has been described as “Canada’s Sixth Great Lake,” bringing a strong provincial and national focus on its critical hydrologic role within the Prairie Water Region, the economic importance of tourism and fisheries, and its major function as a reservoir for hydroelectric power generation (Canada-Manitoba Lake Winnipeg Implementation Committee 2005).

Further, the social and environmental importance which Manitobans attach to Lake Winnipeg’s spirit, beauty, biodiversity, and history is clear. Manitobans care about Lake Winnipeg, and they expect its declining water quality problem to be addressed with effective action (Lake Winnipeg Stewardship Board-LWSB 2005, 2005b).

1.1 The CEC Review

On 8 November 2006, the Minister of Manitoba Conservation requested that the Manitoba Clean Environment Commission (CEC) to “conduct a review and produce a report on the environmental sustainability” of the hog industry in Manitoba (Manitoba Conservation 2006). Central to this review is the following item within its Terms of Reference:

1. The CEC, as a part of its investigation will review the current environmental protection measures now in place relating to hog production in Manitoba in order to determine their effectiveness for the purpose of managing hog production in an environmentally sustainable manner.

In Manitoba one of the largest environmental concerns is the sustainability of its water resources. Recently several organizations, such as the Lake Winnipeg and Lake Manitoba Stewardship boards have been formed to address critical water issues in Manitoba, in particular nutrient loading. Many human activities lead to the movement of nutrients, such as nitrogen and phosphorus entering Manitoba’s waters. Research has been initiated to review the movement and sources of nutrients in Manitoba’s watersheds, but is still in its initial stages.

To fully understand the impacts of particular sectors, such as agriculture or even more specific the hog industry, a total nutrient framework is required that addresses the cumulative impacts of all sectors, and natural nutrient sources on Manitoba’s water resources. The development of framework would include a determination of baseline nutrient data and provide the necessary tools and processes to focus on specific sustainability concerns.

In January 2007, the CEC entered into discussions with the International Institute for Sustainable Development (IISD) to assist in fulfilling its Terms of Reference item #1. In March, IISD produced a concept paper for the CEC. This in turn resulted in the preparation of two research papers (Task 1 and Task 2).

1.2 Task 1 Project Objective

IISD’s Task 1 for the CEC (Total Nutrient Loading Framework) is defined as:

Preparation of a detailed analysis framework describing the watershed pathways and processes associated with “total nutrient loading,” including Manitoba hog industry contributions – with a focus on hydrologic, water quality, and soil management issues.

A hypothetical hog proponent (proponent X), representative of typical hog operations (based on recent development/proposals) in Manitoba will be used to identify cumulative impacts and issues in the Manitoba context.

1.3 Research Methods

In completing Task 1, IISD has conducted the following:

1. A review of relevant nutrient loading literature applicable to Manitoba, with some insights from leading international experiences;
2. A review of relevant hydrologic and watershed management literature, with a focus on nutrient pathways within successively larger watersheds;
3. Consideration of the linkages between anthropogenic contributions of nutrients and watershed processes, with a focus on agriculture within the Manitoba context; and
4. Development of a conceptual analytical framework to guide further analysis of the effectiveness of current environmental protection measures relating to managing hog production in Manitoba.

1.4 Lake Winnipeg within the Global Context

Eutrophication is one of the major forms of water pollution affecting lakes and reservoirs around the world today. The increased nutrient levels through point and non-point loadings from natural and anthropogenic sources leads to the growth of rooted aquatic plants, algal mats, de-oxygenation, and unpleasant aesthetics. The shores of formerly clean lakes develop algal slimes, excessive algal turbidity or dense growth of certain rooted aquatic plants and filamentous algae in shallow areas. As a result, lakes become unattractive for bathing, boating, and other water-oriented recreations. Fish production often increases but the species composition changes for the worst. Economically important species are often replaced by lower economic value species, while increased algae levels interfere with fishing nets and gear (LWSB 2006).

Since 1967, global scientific knowledge regarding the causes, effects, and management responses to address eutrophication has grown dramatically, but the challenge remains:

This explosion of eutrophication-related research has made it unequivocally clear that a comprehensive strategy to prevent excessive amounts of nitrogen and phosphorus from entering our waterways is needed to protect our lakes, rivers, and coasts from water quality deterioration. However, despite these very significant advances, cultural eutrophication remains one of the foremost problems for protecting our valuable surface water resources.

[Smith 2006:351]

Reducing or reversing the eutrophication process can be accomplished by limiting the cumulative effects of nutrient loading from municipal and industrial wastewaters, agricultural wastes and fertilizers, and residential sources (Nakamura and Ahn 2007, Paerl 2006, Schindler 2006, Pers 2005).

Using sound science as a foundation, many social, economic and environmental impacts can be addressed through a variety of policy instruments available to government, including: **institutional** instruments (internal education, strategies, policies, and procedures); **regulatory** (laws, regulations, and enforcement); **direct expenditure** (broad or targeted programs, education and awareness, and research and development); and **economic** instruments (taxes, fees, and incentives). Any policy instrument is comprised of two elements – design and implementation (IISD and TERI 2003).

Application of these policy instruments in the future will have to consider the predicted water quality impacts associated with global climate change projections. Current research predicts increased seasonal variability in water flows, with significant associated nutrient load increases in agricultural and other drainage systems, along with increased eutrophication problems (Schindler and Donahue 2006, Arheimer 2005b).

1.4.1 Responding to the Nutrient Challenge

Understanding the temporal and spatial variations associated with Lake Winnipeg is fundamental to the development of a “scientifically defensible nutrient management strategy,” and there are major information gaps to fill before appropriate and effective nutrient loading criteria can be developed. Determining appropriate watershed and lake monitoring programs and protocols, defining “pristine” lake conditions, and separating natural from anthropogenic nutrient sources are all key issues which need to be considered (North/South Consultants 2006:152-154).

Focusing on nutrients specifically, it has been recommended that:

...a thorough accounting of internal and external sources and sinks of nutrients should be derived and a nutrient balance constructed. This is typically the first step in a lake eutrophication study and the development of nutrient criteria. The particular value beyond the obvious (i.e. the quantification of sources of nutrients) is in the ability to compare all of the relative sources and sinks, including internal cycling. This is especially important from a management perspective as this information is critical for identifying potential mitigation and management options.

[North/South Consultants 2006:157]

In the spring of 2006, the Province initiated a public review of a proposed regulation under the *Water Protection Act* (Water Quality Management Zones for Nutrients) and proposed revisions to the Livestock Manure and Mortalities Management Regulation under the *Manitoba Environment Act* (Manitoba Water Stewardship and Manitoba Conservation 2006).

Late in 2006, the Province of Manitoba significantly increased the use of its water quality management options related to Lake Winnipeg. On November 8, the Minister of Manitoba Conservation announced the following initiatives (Manitoba Government 2006):

- Regulations limiting the use and application of manure and synthetic fertilizer, in accordance with defined *Water Quality Management Zones*;
- New buffer zones to reduce phosphorus and nitrogen, including the use of cosmetic fertilizer in sensitive areas near water;
- Strengthened fines and inspection protocols to meet new nutrient reduction levels;
- Support for research and technology for agricultural producers;
- Referral of Manitoba’s “Water Protection Plan” to the Clean Environment Commission for a full, independent, and public review in terms of its effectiveness; and
- Announcement of a “pause” on further development within the hog production sector, including requesting the Clean Environment Commission to conduct a review of the environmental sustainability of hog operations across Manitoba.

Also, Section 32 of the final report prepared by the Lake Winnipeg Stewardship Board (LWSB) includes a number of recommendations focused directly on the concept of “Matching Nutrient Inputs with Crop Nutrient Requirements and Exports, and Establishing Soil Phosphorus Limits.” These recommendations were developed based on substantial scientific evidence provided by the Manitoba Phosphorus Expert Committee (MPEC 2006), which – in their mandated focus on livestock manure management – concluded that Manitoba should focus on minimizing phosphorus losses from agricultural land to surface water while seeking to balance phosphorus applications with loss rates over the long term (LWSB 2006). In turn, the LWSB recommended the following:

- 32.1 For planning individual livestock operations, the Province of Manitoba should ensure that operators have sufficient land available for new and expanding livestock operations to balance phosphorus application rates with removal rates over the long-term.
- 32.2 The Province of Manitoba should develop a regional terrestrial nutrient budget for Agro-Manitoba which would assist producers, municipalities, and regulators in siting intensive livestock operations and managing manure in an environmentally sustainably manner.
- 32.3 Where excess nutrients are being generated, the Province of Manitoba should work with private industry to develop practical options for treating and exporting manure to nutrient-deficient areas.
- 32.4 The Province of Manitoba should adopt the soil test phosphorus thresholds for agricultural land as recommended by the Manitoba Phosphorus Expert Committee. The Province should also act on the Committee’s recommendation to support research which will help refine soil phosphorus thresholds for varying Manitoba soil types and landscapes.

[Lake Winnipeg Stewardship Board 2006:66]

Recommendation 32.2 relates very closely to the concept of “total nutrient management” as considered in this report. *Total Nutrient Management* is to a great extent a watershed issue in the Manitoba context, and this is the challenge that has been given to the Lake Winnipeg Stewardship

Board to manage – through a process of Integrated Water Resources Management planning and implementation – delivered primarily by Manitoba’s conservation districts.

In early 2007, the Province took further action, assigning additional responsibilities to the Lake Winnipeg Stewardship Board, as follows:

The board will take on additional responsibilities to provide advice to government on the health of Lake Winnipeg and its basins. The main mandate of the Lake Winnipeg Stewardship Board will now be to co-ordinate development of a basin-wide watershed management plan in co-operation with regional watershed authorities led by local conservation districts.

While the board will continue to identify and assist in implementing actions to reduce nitrogen and phosphorus to pre-1970s levels, its mandate will be expanded to provide advice to government on other measures needed to restore health to Lake Winnipeg, such as the identification of pollutants entering the lake. It will be additionally tasked with examining issues impacting the management and ecological sustainability of the lake’s fisheries.

The renewed terms of reference will also mandate the board to prepare periodic “state of the lake” reports, through contact with lake users, communities, scientists and others. These reports will be presented to government and will include information on the status of government action in implementing the board’s recommendations and the status of progress toward reaching nutrient reduction targets.

[Manitoba Government 2007]

1.4.2 Total Nutrient Loading

Before *Total Nutrient Management* can occur, and before a regional terrestrial nutrient budget can be generated for Agri-Manitoba, the International Institute for Sustainable Development (IISD) has proposed that a *Total Nutrient Loading Framework* should first be developed.

A Total Nutrient Loading (TNL) Framework would outline the requirements for effectively examining and monitoring the condition of relevant water bodies and guide modifications in the upstream anthropogenic activities of all composite watersheds – in order to reduce the negative impacts of eutrophication in Lake Winnipeg, ultimately also improving the quality of water throughout Agri-Manitoba. Each contributing drainage area has different nutrient loading effects, depending on the landscape and the activities within each respective watershed. Understanding all nutrient sources and the mitigating effects achieved and possible through sound management of these watersheds will provide an understanding of the relative contributions of each drainage system – to Lake Winnipeg, and to Manitoba’s water quality in general.

A TNL Framework would also provide some useful measurement tools for watershed decision-makers to understand the implications of their actions on the larger region. Land use, planning, and other development activities occurring within various hydrologic units all affect downstream nutrient levels in rivers and lakes beyond the originating drainage area. A TNL Framework increases the knowledge within the region about sources and removals of nutrients as well as particular watersheds of concern. Recognizing the differences between various nutrient sources entering particular water bodies is also important. For example, two very significant (and the most studied) nutrients – nitrogen and phosphorus – have dissimilar pathways from the land into surface water bodies and need to be managed differently.

1.4.3 Defining Nutrient Contributions from Agriculture

As noted by Bourne (2002) and Manitoba Water Stewardship (2006), the relative sources of phosphorus entering Lake Winnipeg would appear to be fairly well understood, and they have been accepted by the Lake Winnipeg Stewardship Board (2006). They are noted in Table 1-1.

Additionally, the relative contributions of nitrogen entering Lake Winnipeg have also been documented (Manitoba Water Stewardship 2006) and accepted by the Lake Winnipeg Stewardship Board (2006). These are outlined in Table 1-2.

It is noted that certain and significant questions remain regarding the relative sources and contributions of phosphorus and nitrogen. Some challenges regarding the comparative methodology utilized by Bourne (2002) have also been raised by Flaten (2003b), specifically the lack of data surrounding loading from “within stream processes” and the dependence on known “direct effluent discharges” from wastewater treatment facilities to estimate in-stream loads. Flaten suggests this likely results in an inaccurate assessment of watershed-based loading (given that part of Bourne’s approach involved estimating watershed-based loads by subtracting in-stream loads from *Total Measured Stream Nutrient Loads* (TMSNL), which were “calculated by multiplying the nutrient concentration by the discharge or flow rate at a specific location in the stream” (Bourne 2002:5).

Prior to Flaten’s raising of this methodological concern, Bourne had previously noted that “release from streambed and streambank sediment,” and “infiltration of ground water” were deemed to be beyond the scope of the preliminary nutrient research, and that these were consequently not considered as part of the TMSNL-based estimates (2002:6).

TMSNL estimates were also compared by Bourne (2002) with an estimate of watershed-based loading through the use of land use export coefficients. Flaten (2003b) also questions this triangulatory approach, implying that the use of four land use types (pasture, cropland, forest, and other) may not accurately represent Lake Winnipeg’s contributing watersheds, given that three of the export coefficients used depend on solely on export values derived from non-Manitoba data.

Also, while Bourne’s dual estimates for total phosphorus generated through watershed-based loading compared similarly for the Red River (1209 tonnes via land use coefficient method vs. 1261 tonnes via TMSNL estimate), they did not compare for the Assiniboine River (1039 tonnes-coefficient vs. 139 tonnes-TMSNL), suggesting serious estimate errors, at least for the Assiniboine River (Flaten 2003b:9 with data from Bourne 2002). In suggesting possible reasons for this discrepancy, Flaten further notes that:

The use of nutrient export coefficients to determine P loading from land use assumes that all land within a particular land use category contributes equally to runoff. However, this concept is inconsistent with present-day hydrological theory on runoff processes. Runoff is highly variable both within and between catchments. Current hydrological modeling practice recognizes that soil type and moisture content, slope, management practices, and other factors besides land use are also important in determining amount of runoff and therefore TP export to the stream. Runoff is generated from various source areas within a catchment, and these areas respond with varying degrees to the intensity of the snowmelt or rainfall event.

[Flaten 2003b:9]

This points to the need for a heightened emphasis on hydrological processes and watershed-based hydrologic management-focused approaches to addressing Manitoba's nutrient challenge.

Flaten offers another approach in attempting to understand watershed-based loads, by using Bourne's data (2002) to compare phosphorus loads immediately upstream and downstream of the heavily urbanized portion of the Red and Assiniboine Basins – the Capital Region in and around the City of Winnipeg:

Bourne et al (2002) reported that the average annual TP load on the Red River downstream of Winnipeg at Selkirk is 4905 tonnes. Upstream of Winnipeg at St. Norbert it is 3103 tonnes. The Assiniboine River at Headingley conveys another 637 tonnes of TP, for a total of 3740 tonnes entering Winnipeg. Therefore, as the Red and Assiniboine course through Winnipeg and on to Selkirk, they gain 1165 tonnes of TP, or 24% of the total annual load delivered to Lake Winnipeg [assuming 4905 tonnes at Selkirk]. This highly developed and urbanized section of river appears to be, therefore, a significant contributor of P.

[Flaten 2003b:9]

Flaten (2003b) also raises a genuine concern over the frequency of nutrient loading data collection in Manitoba, which is not continuous (while flow data is). Total nutrient loads are derived by calculating average flows and sampled nutrient concentrations; short-term fluctuations are missed. Flaten cites Rekolainen (1991) in suggesting that determining total phosphorus loads in this manner creates the possibility of underestimating total loading by 40%. The need for increased monitoring to clarify actual trends is obvious.

It is fundamental to note that the Bourne (2002) work was intended to be a “preliminary estimate” of total nutrient loads, as noted in the report title. However, the loading estimates, relative sources, and composite waterway concentrations have not been effectively challenged or revised with additional research beyond periodic updates by Manitoba Water Stewardship (2006), based on existing data collection protocols.

It is both conceivable and likely that arguments will persist among those individuals who and organizations which have particular interests in the direction of future institutional, regulatory, expenditure, and economic policy directions taken by the Province of Manitoba. Without more frequent and detailed monitoring of nutrient loading – to better understand how each contributing drainage system influences total nutrient loading downstream, and ultimately Lake Winnipeg – these rather poorly informed debates will continue.

It has been suggested by some researchers, that the resulting lack of clarity regarding relative nutrient contributions received from both Upstream and Manitoba sources (and the “level partitioning” which occurs within each source, particularly the Manitoba-based load estimates) represents a “failure of science.” Whether a failure or simply the very beginning of real understanding, it needs to be addressed through more frequent and detailed monitoring, combined with a continued exploration of improving methods for understanding how Lake Winnipeg's composite watersheds each contribute to the health of this iconic water body – and to Manitoba's water quality in general.

For the purposes of this report, the nutrient loading data accepted by the Lake Winnipeg Stewardship Board will be assumed to accurately represent the relative sources and composite watershed contributions as we currently understand them, represented by Table 1-1 and Table 1-2.

Category	Average Total Phosphorus (t/yr)		% of Total Phosphorus to Lake Winnipeg (% of Manitoba sources)	
Upstream jurisdictions	4,200		53%	
United States (Red River)		2,500		32
United States (Souris River)		200		3
Saskatchewan and Alberta (Assiniboine and Saskatchewan)		400		5
Ontario (Winnipeg River)		800		10
Ontario (Other rivers)		300		3
Manitoba Sources	3,700		47%	
Manitoba Point Sources		700		9 (19)
City of Winnipeg (Wastewater sources)		400		5 (11)
All others (Wastewater sources)		300		4 (8)
Manitoba Watershed Processes		2,500		32 (67)
Natural background & undefined sources**		1,300		17 (35)
Present day agriculture		1,200		15 (32)
Atmospheric Deposition		500		6 (14)
Internal Lake Processes	Currently there are no estimates available for internal phosphorus cycling that may occur in the lake.			
Overall annual total phosphorus load to Lake Winnipeg	7,900		100%	
<p>* An update of these loading figures is currently being prepared by Manitoba Stewardship. **Estimated natural background and undefined sources would also include contributions from sources such as forests, wildlife and septic fields.</p>				

Table 1-1: Summary of estimated annual phosphorus loading to Lake Winnipeg 1994-2001 (tonnes per year rounded to nearest 100 tonnes). Source: Bourne 2002 and Manitoba Water Stewardship 2006

Category	Average Total Nitrogen (t/yr)		% of Total Nitrogen to Lake Winnipeg (% of Manitoba sources)	
Upstream jurisdictions	48,900		51%	
United States (Red River)		19,000		20
United States (Souris River)		1,100		1
Saskatchewan and Alberta (Assiniboine and Saskatchewan)		8,300		9
Ontario (Winnipeg River)		16,800		17
Ontario (Other rivers)		3,700		4
Manitoba Sources	47,100		49%	
Manitoba Point Sources		5,100		5 (11)
City of Winnipeg (Wastewater sources)		3,700		4 (8)
All others (Wastewater sources)		1,400		1 (3)
Manitoba Watershed Processes		23,200		24 (49)
Natural background & undefined sources**		18,100		19 (38)
Present day agriculture		5,100		5 (11)
Atmospheric Deposition		9,500		10 (20)
Internal Lake Processes - Nitrogen Fixation***		9,300		10 (20)
Overall annual nitrogen load to Lake Winnipeg	96,000		100%	
<p>* An update of these loading figures is currently being prepared by Manitoba Stewardship. **Estimated natural background and undefined sources would also include contributions from sources such as forests, wildlife and septic fields. *** Nitrogen fixation: it has been estimated that species of blue-green algae are adding about 9300 tonnes of total nitrogen per year to Lake Winnipeg, by fixing the nitrogen gas found in the atmosphere.(Source: Len Hendzel, DFO, Winnipeg, 2006).</p>				

Table 1-2: Summary of estimated annual nitrogen loading to Lake Winnipeg 1994-2001 (tonnes per year rounded to nearest 100 tonnes). Source: Manitoba Water Stewardship 2006

Based on these tables and the data from which they were generated (Bourne 2002 and Manitoba Water Stewardship 2006), Manitoba Sources of phosphorus and nitrogen are categorized as *Manitoba Point Sources*, comprising industrial and domestic wastewater from the City of Winnipeg and various other sources, including licenced wastewater lagoons serving rural “towns and villages, Hutterite colonies, provincial parks, community centres, schools, and churches” (Bourne 2002:21).

Additionally, *Manitoba Watershed Processes* include nutrient loads contributed from various “natural background and undefined sources” (including forests, wildlife, and septic fields (LWSB 2006:25-26), along with “present day agriculture” sources. These two sources are interrelated, given the defining role of “land use” in determining total nutrient loads, given that:

The load of nutrients from the land to surface water depends on soil type, vegetation cover, and precipitation. The type of land use practices or activities also heavily influences the movement of nutrient from land to surface waters. Rates of nutrient export can be lowered by the presence of riparian vegetation along stream channels and lake shores, while the development of drainage channels can have the opposite effect and result in increased nutrient export to surface waters. The amount of nutrient loading to land from atmospheric deposition and agricultural fertilizer and manure applications can also strongly influence the amount of nutrients that are available for export to surface waters.

[Bourne 2002:30]

As outlined by Bourne (2002), the nutrient export coefficients of four land use categories (pasture, cropland, forest, and other) were utilized to estimate total nutrient loads for Lake Winnipeg arising from within Manitoba. These coefficients were based partially on data from Manitoba (South Tobacco Creek) and largely on data from South Dakota, North Dakota, Minnesota, and Wisconsin.

Each of these sources (natural background/undefined and agriculture) are very significant, and when combined as *Manitoba Watershed Processes*, together comprise 2,500 tonnes/year of phosphorus (approximately 32% of total phosphorus loads) and 23,200 tonnes/year of nitrogen (approximately 24% of total nitrogen loads) entering Lake Winnipeg (LWSB 2006:25-26).

As noted earlier, Section 32 of the LWSB final report provides important guidance regarding *Total Nutrient Loading* in Manitoba and nutrient contributions from agriculture, particularly phosphorus. The critical importance of “matching nutrient inputs, whether livestock manure or synthetic fertilizer, with crop requirements” is noted as a central focus for reducing total nutrient loads entering Lake Winnipeg (LWSB 2006:64).

To better understand how the hog industry may be influencing both local and downstream water quality – in the search for assurances that this sector is sustainable, or to implement policy tools to ensure that it is – we must understand how hog production (relative to other types of agricultural production) influences *Manitoba Watershed Processes*.

2 Understanding Downstream Nutrient Loading

Several natural and anthropogenic processes contribute to the total nutrient load in any given water body. Each contributing drainage system will have different sources of nutrients, depending on the type of landscape features, soil types, land use and human activities within its particular drainage area. Understanding the biophysical interrelationships between these different variables and the various differences between the composite watersheds of a larger system (in addition to any interrelationships between these composites) is fundamental to understanding total nutrient loading within a larger system, such as a river or lake basin.

In terms of Lake Winnipeg, it is also useful to consider the “source-sink” logic often utilized by environmental scientists in understanding the interrelationships between contributing pollution sources and their downstream impacts. Harper (2004) frames this discussion in terms of the broad “ecosystem services” provided by earth’s finite resources, including water. In terms of the specific ecosystem services which humans value the most:

You can conceptualize the earth as a system of *sources* (from which resources are drawn) and *sinks* (into which human wastes and effluents go)...In simpler words, sources function as “supply depots” and sinks function as “waste repositories” (Dunlap and Catton 2002). This is an abstract way of talking about the functions of the environment for people. A sink can refer to a trash dump, a river, or the atmosphere, which absorbs wastes of different kinds.

[Harper 2004:85]

For the purpose of this report, the various “sources” of nitrogen and phosphorus loading will be explored, with the understanding that as a “sink,” Lake Winnipeg is currently receiving contributions of these nutrients in the ratio of 12:1, based on annual loads of 96,000 t/yr of nitrogen and 7,900 t/yr of phosphorus (LWSB 2006:25-26).

Additional emphasis will be placed on phosphorus, due to its previous identification as the primary cause of Lake Winnipeg eutrophication, most clearly by the Lake Winnipeg Implementation Committee:

Phosphorus is the nutrient that determines the amount of algal growth, because its supply in nature is limited....Efforts to control the eutrophication should focus first on reducing phosphorus loading. When efforts are directed to reducing both nitrogen and phosphorus, the ratio of nitrogen to phosphorus entering the system should be maintained above 15:1.

[LWIC 2005:17]

2.1 Lake Eutrophication

The gradual increase of nutrient levels and sediment in a lake is called lake eutrophication. Eutrophication occurs normally in nature as nutrients accumulate in a water body from its associated watershed. Coastal Environmental/PBS&J (1998) has outlined the progression of eutrophication in a typical lake through the following series of phases or trophic states:

Oligotrophy - nutrient-poor, biologically unproductive, low turbidity;

Mesotrophy - intermediate nutrients and biological productivity, moderate turbidity;

Eutrophy - nutrient-rich, high biological productivity, high turbidity; and

Hypereutrophy - the extreme end of the trophic continuum

Coastal Environmental/PBS&J (1998) further describe three key steps in the eutrophication process once the nutrients concentrations reach sufficient levels to promote increased algal blooms:

- 1) The increased algae concentrations block the light that supports plant growth, thereby reducing aquatic vegetation;
- 2) The increased amount of decaying algal cells settling on the lake bottom decreases the available oxygen in the water, result in larger fish kills; and
- 3) Once the dominant source of primary production in the lake is algae, the fish population can shift from mainly a carnivorous sport fish to a more of a herbivorous rough fish.

Lakes and streams are susceptible to increasing biochemical oxygen demand (BOD) loads caused by the decomposition of algal blooms as well as other organic matter. BOD is the amount of oxygen required to decompose the organic matter in the water using aerobic biochemical action and is commonly used to determine the impact of sewage effluents or spills from livestock production (Mallin 2006). Increasing nutrient inputs within an upstream watershed will stimulate algae growth, which can significantly increase the subsequent downstream BOD load in rivers and lakes, resulting in hypoxia (oxygen depletion) problems, such as fish kills and decreasing a lake's natural lifespan.

While natural eutrophication processes do impact a lake's lifespan, anthropogenic eutrophication can drastically shorten the time it takes for an affected lake to reach a hypereutrophic state (Smith 2006). Activities within the lake's contributing watershed such as forest clearing, road building, agricultural cultivation, residential and commercial development, stormwater runoff and wastewater discharges can all result in substantial increases in the discharge of nutrients to the water.

The impacts of eutrophication, such as algal growth and periodic fish kills, were identified as significant concerns as early as the 1950s (Schindler 2006). At this time, most research and mitigative attempts focused on treating the symptoms with copper sulfate and herbicides to control the algal blooms. During the 1960s, however researchers were able to link the increasing algal growth with the increased nutrients entering the lakes due to human activities (Schindler 2006; Smith 2006). Eutrophication research conducted during the 1970s demonstrated unequivocally that controlling phosphorus loading is the key factor in addressing lake eutrophication:

As the result of accumulating evidence from limnologists, phosphorus control became the standard policy in most first-world countries. Many studies showed that controlling point sources of phosphorus effectively reduced eutrophication (e.g. Edmonson 1970; Ahlgren 1978; Holtan 1981). In 1974, a resolution was read at the 19th International Congress of the International Limnological Society (SIL): "Because of the critical role of phosphorus in the rapid eutrophication of inland waters, be it resolved that in addition to secondary treatment of sewage it is necessary to control additions of this element into any inland water." Phosphates in cleaning products, sewage, septic tanks, and agricultural wastes were specified in subsequent wording. The resolution was carried by the roughly 1,000 delegates at the Congress.

[Schindler 2006:358]

Projected climate change impacts for the Canadian Prairies include warmer temperatures, less precipitation, and lower water levels (Hengeveld, 2006). The impacts of these changes could exacerbate the rate of eutrophication in Manitoba's lakes, particularly due to increased water residence times (resulting from reduced inflows from contributing streams and increased evaporation rates), which have been demonstrated to increase nutrient retention in lakes where point sources of nutrients are the primary loading contributor (Schindler 1978 in Schindler 2006). In lakes where non-point sources are the main component of nutrient loads, lake eutrophication impacts may in fact be reduced through climate change impacts such as reduced stream flows; however, associated decreases in silica loads may trigger earlier seasonal Cyanobacteria blooms (Schindler 1996 in Schindler 2006). In cases where both point and non-point sources are significant contributors to lake nutrient loading, the projects impacts of climate change are not yet clear (Schindler 2006).

Many lakes on the Canadian Prairies are shallow and have underlying soils which naturally contain high concentrations of phosphorus. During recurring periods of hypoxia during calm summer weather, high levels of phosphorus can be released from lake sediments. Subsequent windy weather causes this phosphorus to be mixed upward within the water column, raising overall phosphorus levels in the lake. In some lakes, this "internal loading" can serve as the primary source of phosphorus and eutrophication, exceeding anthropogenic and other sources (Schindler 2006:359). These sources are discussed further in Section 2.3.1, with particular reference to Lake Winnipeg.

2.2 Cumulative/Total Loads

All healthy ecosystems require nitrogen and phosphorus; they are essential components of life. These nutrients are found naturally in the environment and can also naturally exist in excess levels depending on the characteristics of particular ecosystems. Several human activities have the potential to increase the levels nutrients found within an ecosystem, and this may also occur through the movement of nutrients between ecosystems. For example, agriculture tends to import nutrients through the use of various types of fertilizer, and some of these nutrients may be introduced into the watersheds of an ecosystem through different land use practices and land management techniques. Different types of land use and management can greatly influence the rate at which nutrients may enter the watersheds of an ecosystem, as well as influence the rate at which nutrients become available for algal growth downstream (Bourne 2002).

The water quality of particular lakes is largely influenced by the quality of surface water runoff which is collected within its contributing watersheds. Accurately understanding the transport mechanisms and ultimate fate of nutrients and other materials carried by this runoff is central to understanding water quality within a downstream lake. Agriculture, urban development, mining, forestry, and other land use practices all influence the frequency, volume, and quality of this surface runoff, increasing the likelihood that anthropogenically-generated nutrients will enter a lake's contributing watershed. Both point and non-point sources of anthropogenic nutrient loading are generally associated with increased levels of nitrogen and phosphorus in watersheds, resulting in serious threats to downstream water quality (Soranno 1996).

Flaten notes that “many wastewater treatment plants in jurisdictions upstream of Manitoba have installed nutrient removal facilities” (2003b:15). With this increasing abatement of point-source sources of downstream eutrophication (i.e. in Lake Winnipeg), the prime focus in addressing eutrophication should logically be associated mainly with non-point nutrient sources.

The Lake Winnipeg Stewardship Board has accepted that one of Lake Winnipeg’s composite watersheds – the Red River Basin – appears to be the dominant source of nutrient loading for the lake, contributing 54% of total phosphorus and 30% of total nitrogen (2006:29). Unfortunately, as pointed by North/South Consultants (2006), the movement of nitrogen and phosphorus is extremely complex, with several entrance pathways within Lake Winnipeg’s composite watersheds, and indeed the contributing drainage systems within the Red River Basin itself, a predominantly agricultural landscape.

Bourne (2002) has developed a useful schematic depiction of Lake Winnipeg nutrient loading. These are presented as Figure 2-1 and 2-2 and serve as a foundation for the development of a *Total Nutrient Loading Framework*. However, a more thorough quantification of runoff, sediment yield, and nutrient loadings from each of Lake Winnipeg’s composite watersheds is required to accurately evaluate the effects of the myriad land use activities and management practices which are occurring within these contributing drainage systems.

The LWSB’s acceptance of the Bourne (2002) and subsequent Manitoba Water Stewardship (2006) nutrient loading data implies that, of all Lake Winnipeg’s composite watersheds, the Red River Basin (including its own composite subbasins, watersheds, and subwatersheds) should be the first priority system for addressing non point source loading to Lake Winnipeg. Exploring the interrelationships between land use and hydrology shall be the increasing focus of subsequent sections of this report, including in-depth consideration within Section 3.

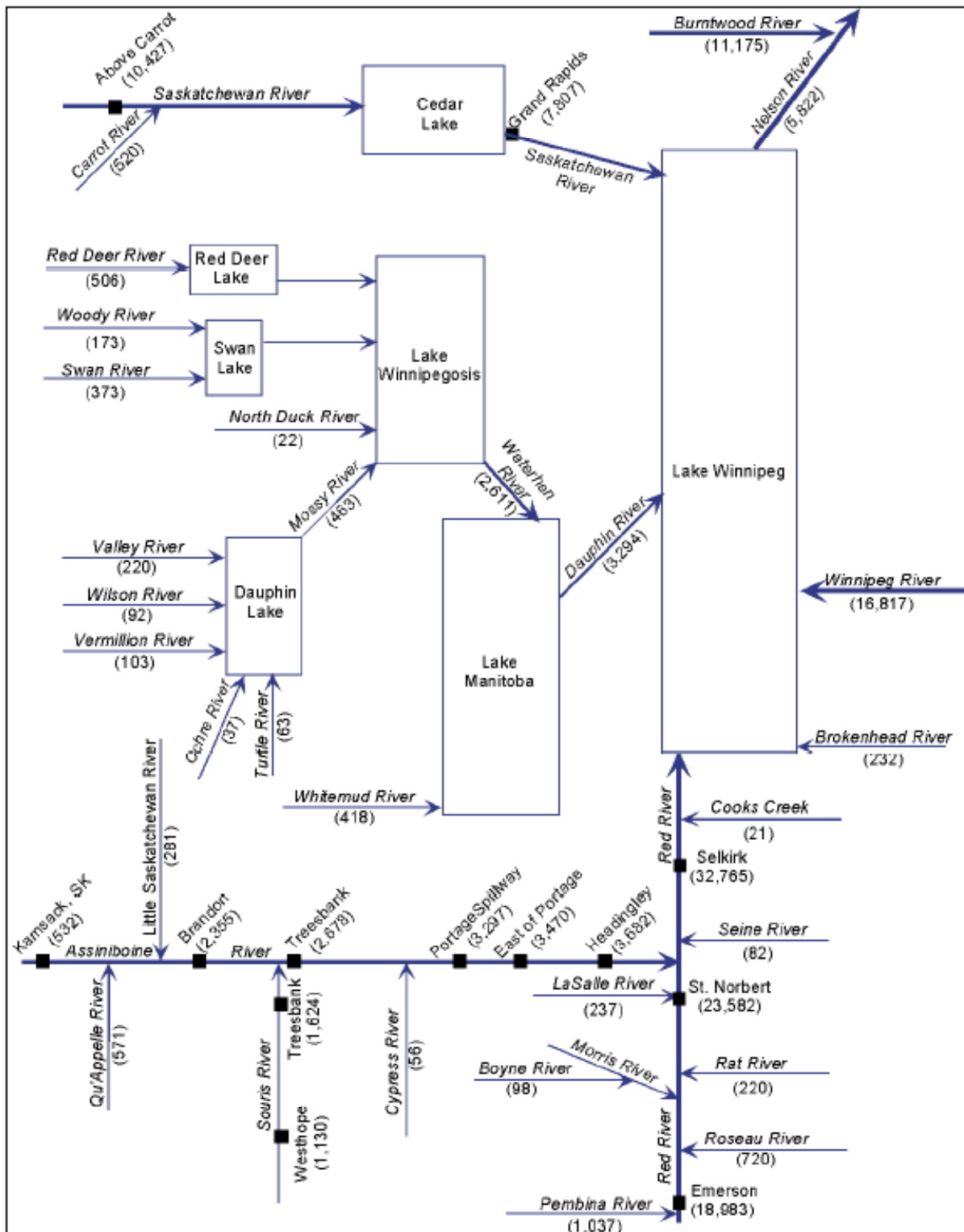


Figure 2-1: Schematic diagram of mean annual total nitrogen load *t/yr) in streams at long-term monitoring stations in Manitoba (1994-2001). Source: Bourne 2002:13

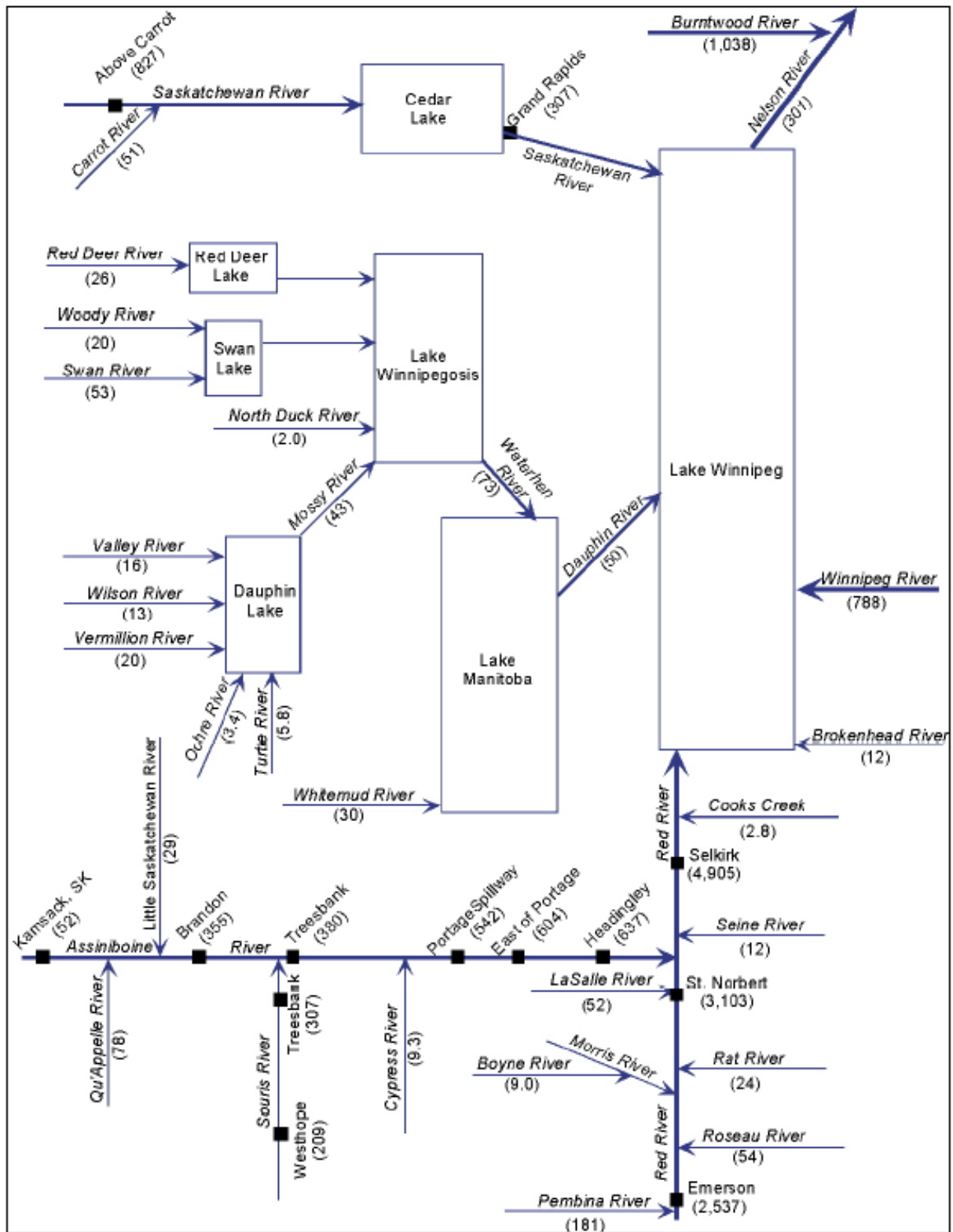


Figure 2-2: Schematic diagram of mean annual total phosphorus load (t/yr) in streams at long-term monitoring stations in Manitoba (1994-2001). Source: Bourne 2002:14

2.3 Nutrient Sources

Using the typology adopted by the Lake Winnipeg Stewardship Board (2006), nutrient loads entering Lake Winnipeg are contributed from the following sources:

- *Internal Lake Processes* (unknown for phosphorus, estimated at 9,300 t/yr nitrogen);
- *Atmospheric Deposition* (estimated at 500 t/yr phosphorus and 9,500 t/yr nitrogen);
- *Upstream Jurisdictions* (United States, Ontario, Saskatchewan, and Alberta), entering via the Red, Souris, Assiniboine, Saskatchewan, Winnipeg, and other river systems;
- *Manitoba Point Sources* (industrial and domestic wastewater from the City of Winnipeg and various other sources in rural Manitoba); and
- *Manitoba Watershed Processes* (including natural background loading, undefined sources, and present-day agriculture – all of which are interrelated to a significant degree)

2.3.1 Internal Lake Processes

Based on data from Fisheries and Oceans Canada, natural fixation of atmospheric nitrogen by blue-green algal communities has been estimated to contribute 9,300 t/yr of nitrogen to Lake Winnipeg, representing 10% of total nitrogen loading (LWSB 2006:27). Internal lake contributions of phosphorus are not well understood, and are not estimated.

North/South Consultants has noted that:

Sediments typically serve as “sinks” for nutrients and other substances, including contaminants, and lake therefore retain nutrients. Phosphorus settles, most notably in particulate forms, to lake sediments and is precipitated as insoluble ion, calcium, or aluminum phosphates.

However, under certain conditions, sediments may be net sources of nutrients. Internal loading refers to the release of nutrients (typically phosphorus) from the sediment to the overlying water column, thereby effectively behaving as an “internal” nutrient load.

Physiochemical and biological conditions at the sediment-water interface that affect the occurrence of internal loading are: phosphorus saturation of sediments; low dissolved oxygen conditions; elevated temperatures; reducing conditions; turbulence; pH and temperature; biological activities of sediment biota; and iron availability.

[North/South Consultants 2006:82-83]

Supported by an exhaustive review of the limnological literature, North/South Consultants note that internal lake nutrient loading appears to be a major source of nutrients which can continue to affect lake water quality for long periods of time, even after loads flowing into a water body have been substantially reduced. Also, “internal loading appears to vary over the year, typically being greatest in summer in shallow temperate lakes” (2006:85).

Based on analyses by Sondergaard (2003 and 2001 in North/South 2006), it has been suggested that internal loading within shallow lakes can in fact be the single greatest source of nutrients. Phosphorus may be released from shallow lakes through diffusion (via decomposition of organic

material). Also, “shallow lakes an/or the nearshore areas of lake may also experience wind-driven sediment resuspension that can also introduce significant quantities of nutrients into the water column (James 2005 in North/South 2006:83).

2.3.2 Atmospheric Deposition

As noted by Bourne, “nitrogen and phosphorus can be deposited directly to land and water through rainfall and particulate deposition through the air. Nutrients can be deposited directly to surface waters as well as onto the land surface and then transported to surface waters” (2002:6-7). Citing Schindler (1976), Flaten also notes there are three pathways for phosphorus deposition: dry/particulate attached to dust and other matter, wet/dissolved in precipitation, and phosphine gas (primarily generated by wetlands) 2003b:12).

The relative contributions of these sources are not well understood, although some interesting research in Manitoba and beyond is cited by Flaten (2003b). Atmospheric contributions to Lake Winnipeg are estimated and accepted to be 500 t/yr of phosphorus and 9,500 t/yr of nitrogen, representing 6% and 10% of total nutrient loads respectively (LWSB 2006:25-26).

2.3.3 Upstream Jurisdictions

The contributing drainage area for Lake Winnipeg is approximately 953,000 km² while the lake itself is 23,750 km², resulting in a very high contributing drainage area – surface area ratio of 40:1 (LWSB 2006:4 and LWIC 2005:11). Given that Lake Winnipeg’s drainage area is so large, accurately understanding and addressing the sources of upstream nutrient contributions is very problematic. This is primarily due to the fact that land in no less than three Canadian provinces and four US states collectively contributes nutrient loads to Lake Winnipeg, in addition to Manitoba’s own nitrogen and phosphorus contributions.

Each of these jurisdictions contribute its own point source, atmospheric deposition, natural background, undefined, and present-day agriculture nutrient loads. At 4,200 t/yr of phosphorus and 48,900 t/yr of nitrogen, the Lake Winnipeg Stewardship Board has accepted that nutrient loads from upstream jurisdictions contribute 53% and 51% of total phosphorus and nitrogen loading to Lake Winnipeg (2006:25-26).

Overall, the Lake Winnipeg drainage area contains more than 65 million ha (650,000 km²) of agricultural land, representing more than 68% of the entire landbase. In a given year, at least 50% of this agricultural land is cultivated (LWIC 2005:12), with the remaining amount reasonably expected to be in pasture, forage rotation, or zero-tillage. Based on Canadian and US statistical data, the Lake Winnipeg Stewardship Board estimates the presence of more than 12 million beef cattle and almost 15 million hogs (LWSB 2006:13).

Nutrient loading data provided by Manitoba Water Stewardship (2006), for the major river systems entering Lake Winnipeg has also been accepted by the Lake Winnipeg Stewardship Board (2006) and is presented in Chart 2-1 and 2-2 below. The Red, Assiniboine, and Saskatchewan River systems each comprise substantial contributing drainage areas beyond the borders of Manitoba. However, the Red River is clearly the dominant nutrient source for both phosphorus and nitrogen.

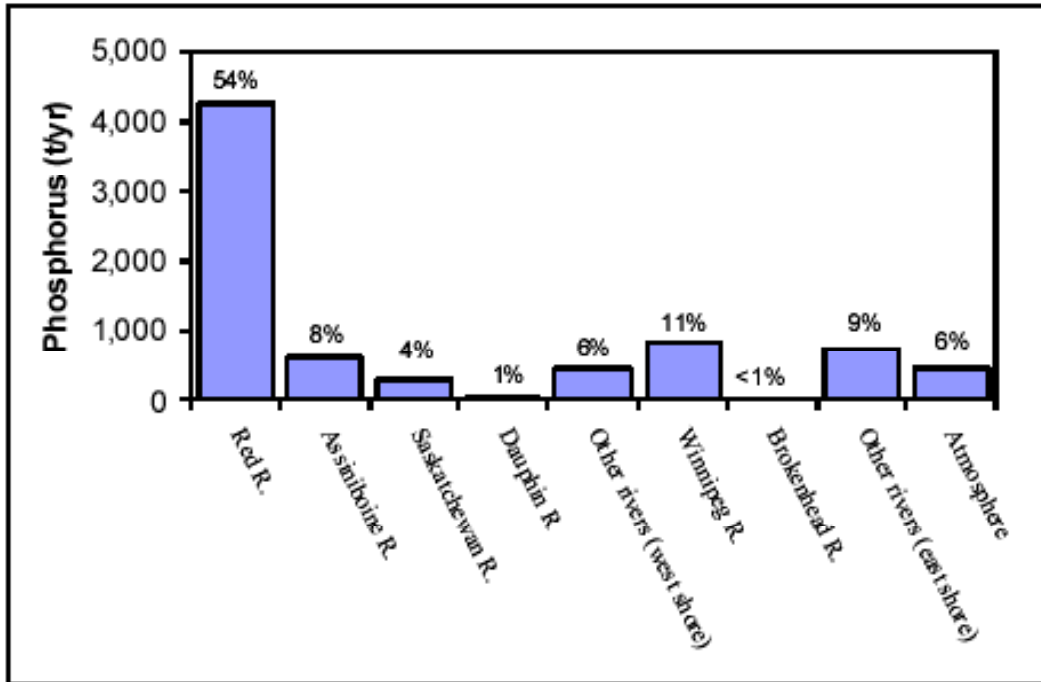


Chart 2-1: Total phosphorus loading to Lake Winnipeg from contributing sources, 1994-2001 (t/yr).
Source: Manitoba Water Stewardship 2006 in LWSB 2006:29

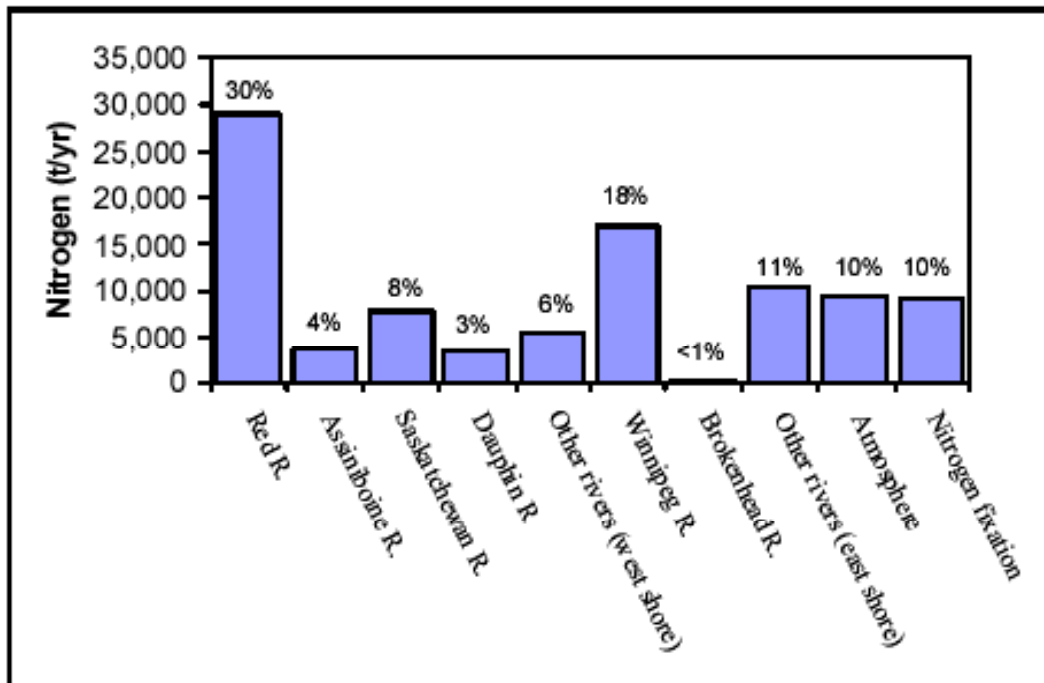


Chart 2-2: Total nitrogen loading to Lake Winnipeg from contributing sources, 1994-2001 (t/yr).
Source: Manitoba Water Stewardship 2006 in LWSB 2006:29

As noted in Section 1.1.3, within a predominantly agricultural landscape there are necessarily strong interrelationships between natural background, undefined, and present-day agriculture nutrient loading sources. Together, these may be defined as *Upstream Jurisdiction Watershed Processes* and form a significant portion of total Upstream Jurisdiction contributions.

This reality is evident when considering the disproportionate nutrient contributions (54% of total phosphorus and 30% of total nitrogen) entering Lake Winnipeg via the Red River, which supplies only 11% of water flows (LWSB 2006:20,29). In addition, as noted by Williamson (2003) in Flaten (2003b), 59% of all Red River phosphorus loads are estimated to originate in the United States.

Substantial cooperation efforts exist and/or are underway within the three main drainage systems which contribute nutrients to Lake Winnipeg from beyond Manitoba. These likely represent the best means of addressing extra-provincial nutrient loads and are discussed further in Section 3.

However, activities in Manitoba – the source of almost half of total phosphorus loading entering Lake Winnipeg – are clearly a provincial priority which needs to be addressed now.

2.3.4 Manitoba Point Sources

At 700 t/yr of phosphorus and 5,100 t/yr of nitrogen, these sources are estimated to contribute 9% of total phosphorus and 5% of total nitrogen loads to Lake Winnipeg respectively (LWSB 2006:25-26). Point sources are most clearly defined as “direct effluent discharges...from industrial operations, domestic wastewater treatment facilities (includes wastewater treatment lagoons and wastewater treatment plants), and urban stormwater drains” (Bourne 2002:20-21).

Sizable wastewater treatment plants exist in Winnipeg, Brandon, and Portage la Prairie while many other rural “towns and villages, Hutterite colonies, provincial parks, community centres, schools, and churches” (Bourne 2002:21) manage wastewater treatment lagoons and are licenced to discharge their effluent into Manitoba surface waters. The Lake Winnipeg Stewardship Board’s nutrient loading estimates were based on the research conducted by Bourne (2002) with additional information provided by Manitoba Water Stewardship (2006). These estimates are based on a combination of per capita nutrient loading estimates and actual measured discharges from larger municipal wastewater treatment facilities and industrial operations. Federally regulated facilities such as First Nations and national parks were not included due to a lack of available data.

Bourne notes that very few of the 400 licenced wastewater treatment facilities in Manitoba are required to monitor their effluent for nitrogen and phosphorus; neither do most of the 32 licenced industrial operations with wastewater discharges. Most industrial effluent is managed by municipal wastewater treatment facilities, while (beyond a small number of large industrial operations), industrial nutrient loading is likely underestimated (2002:21-24).

Stormwater and land drainage runoff contributions are another source of Lake Winnipeg nutrient loading from the City of Winnipeg. These contributions occur in the form of “combined sewer overflows, land drainage sewer discharges, and emergency sanitary overflows.” There are 76 combined sewer and 90 land drainage sewer outfalls entering rivers within the City of Winnipeg (Bourne 2002:22).

Combined sewer overflows occur when combined domestic-land drainage sewer systems within 70% of Winnipeg discharge directly to the Red and Assiniboine Rivers during periods of heavy rain and snowmelt, known as “wet weather flows” (Flaten 2003b:14). Emergency sanitary overflows may also occur during wet weather flow periods when Winnipeg’s wastewater treatment plants cannot effectively treat all receiving wastewater (Flaten 2003b), or during periods of critical maintenance or system malfunction.

Land drainage sewers carry the precipitation runoff from developed urban areas, initially collected via the street-based network of collector sewers, directly to an adjacent water body. Data cited by Flaten (2003b) from the Wisconsin Department of Natural Resources (1991) suggests that combined industrial/commercial phosphorus loading from developed areas can easily double those generated by single-family and multi-family dwelling community areas. However, Flaten also cites other data collected in the City of Madison, noting that “the authors found lawns and streets to be the most significant sources of phosphorus in the test basins” (Waschbusch 1999), while Bannerman (1993) found that “lawns in residential and industrial areas contributed 14% and 44% respectively of the phosphorus load to stormwater runoff” (2003b:16).

Flaten raises the following important points regarding wastewater treatment:

Another distinct characteristic of the effluent from water treatment facilities is that almost all of the total phosphorus is soluble phosphorus, and therefore its effect on the environment will be much acute than other sources where the dissolved phosphorus fraction of total phosphorus is not as high.

Currently, wastewater treatment facilities within the Manitoba portion of the Red River watershed lack nutrient removal systems. However, many wastewater treatment plants in jurisdictions upstream of Manitoba have installed nutrient removal facilities.

Wastewater treatment facilities also create a sludge by-product, usually referred to as “biosolids.” This material, a residue from primary and secondary treatment processes, is dewatered to various extents and then land applied, much like manure. The amount of biosolids generated by a wastewater treatment facility depends on the level and type of treatment processes. The disposal of biosolids continues to be a major concern for wastewater treatment facilities across the continent.

[Flaten 2003b:12]

While wastewater primary and secondary sewage treatment serves to remove most solids, sediment, and organic material (in addition to killing pathogens), it is important to note that wastewater treatment in Manitoba does not yet remove nutrients, which would be tertiary treatment (Cunningham 2007). Land application of biosolids does result in some total phosphorus reduction from the wastewater. While the dissolved phosphorus portion is less of a concern with biosolids (Flaten 2003b), this treatment process basically involves nutrient relocation. Biosolids are often applied to agricultural lands as a fertilizer supplement, and the potential for some nutrients to reenter a drainage system via erosion and runoff seems plausible. High toxicity and the presence of heavy metals necessitates the burial or incineration of most sewer sludges (Cunningham 2007).

Table 2-1 provides a useful overview of all Manitoba Point Source nutrient loads to Lake Winnipeg.

Source	TN (t/yr)	TP (t/yr)
Winnipeg (includes industry)		
NEWPCC	2,569	232
SEWPCC	516	82
WEWPCC	226	40
Land drainage sewers	201	20
Combined overflow sewers	79	16
Winnipeg Total	3,591	390
Brandon (estimated)	129	17
Portage la Prairie (includes industry)	88	32
Other WWTF (estimated)	1,180	161
Other industrial facilities	181	67
Provincial Total	5,170	667

Table 2-1: Average nutrient loads (t/yr) from effluent discharges to surface waters in Manitoba.
Source: Bourne 2002:24

2.3.5 Manitoba Watershed Processes

As discussed in Section 1.1.3, the various nutrient loads supplied by “natural background and undefined sources” (including forests, wildlife, and septic fields, along with “present day agriculture” sources are interrelated. Together, these *Manitoba Watershed Processes* comprise 2,500 tonnes/year of phosphorus (32% of total phosphorus loads and) and 23,200 tonnes/year of nitrogen (24% of total nitrogen loads) entering Lake Winnipeg (LWSB 2006:25-26).

Nutrient loads from Upstream Jurisdictions are a substantial source of Lake Winnipeg nutrient loading, and solutions in this area will likely require long-term bilateral discussions between Canada and the United States. In addition to interprovincial discussions between Manitoba, Saskatchewan, and Ontario. However to date, most local attention, action, and resources have been devoted to City of Winnipeg and other rural and industrial Manitoba Point Source nutrient contributions, reportedly because “these sources are the easiest to identify and manage” (LWSB 2006:27).

The Lake Winnipeg Stewardship Board notes that nutrient loads generated via *Manitoba Watershed Processes* (primarily via the Red River) are in fact much more significant than Manitoba Point Source contributions of phosphorus (more than threefold at 32% vs 9%) and nitrogen (almost fivefold at 24% vs 5%), also noting that:

It is also clear that the contributions from the Red River watershed are high in comparison to the other major rivers in Lake Winnipeg’s watershed, even though the Red River contributes considerably less flow (*11% of contributing flows*). Both the naturally fertile soils of this region and the intense residential and agricultural development contribute to this nutrient loading.

The dominant form and process of phosphorus loading from the watershed appears to be as dissolved phosphorus during the spring runoff. The application of appropriate beneficial management practices on the landscape to reduce loading during the spring will be an important measure to improve water quality of streams feeding Lake Winnipeg.

The relatively high contribution of nutrients originating from upstream jurisdictions (51 % of the nitrogen and 53% of the phosphorus) accentuates the need to work in cooperation with neighbouring provinces and states to reduce loading to Lake Winnipeg, and also to lead by example.

[Lake Winnipeg Stewardship Board 2006:27]

Manitobans should be most concerned by the LWSB's acknowledgement that *Manitoba Watershed Processes* in fact represent 67% of all phosphorus loads generated within Manitoba and 49% of all nitrogen loads entering Lake Winnipeg from within the province. For phosphorus, watershed processes are reported to almost evenly comprised of "natural background/undefined" at 35% of Manitoba-based sources and 32% "present day agriculture." Manitoba-based loads for nitrogen are reported to be 38% "natural background/undefined" and 11% "present day agriculture" (LWSB 2006:25-26).

Manitoba's current and major challenge now is in fact to lead by example, in finding and implementing methods to reduce nutrient loading to Lake Winnipeg, contributed via *Manitoba Watershed Processes*. These include the following sources.

2.3.5.1 Natural Background and Undefined Loading

A wide variety of natural and human activities on the landscape can affect Lake Winnipeg water quality, in particular the nutrient loads which enter through its composite watersheds. Precipitation falling in the form of rain or through spring runoff flows downstream to the lake and is dramatically influenced by topography, soils, human-induced landscape change, and the contributing drainage systems through which water flows (whether natural streams or agricultural drains).

While these are natural processes, various land use activities and landscape changes can result in dramatic alternations to natural systems, causing impacts such as: increased streamflows and associated erosion and sediment transfer and deposition in and via waterways; increased soil erosion from the land into downstream waterways; increased nutrient loading associated with different agricultural vegetation types or a lack of beneficial riparian vegetation; contamination of groundwater and subsequent nutrient flow into receiving waterways; increased nutrient transport associated with agricultural and residential land drainage; and nutrient loads associated with rural residential septic field systems. These sources are described within the Manitoba context below.

Forests, Vegetation, Wildlife, and Soils

Erosion causes nutrients to be released from decaying forest litter and organisms, while other forms of decaying vegetation also export nutrients downstream via surface water runoff following precipitation events or meltwater. Various land use practices alter the amount of exposed soil in particular areas, as well the type and mass of vegetation available for decomposition (Bourne 2002).

Forested watersheds provide valuable ecosystem services, including the sequestration of nutrients (Sidle 2006) and the removal of forest cover has been demonstrated to increase annual runoff and sedimentation rates measured in downstream waterways (Foster 2005). Dissolved forms of most nutrients have been identified as the largest sources of forest-related nutrient export downstream (Yusop 2006). Some of Lake Winnipeg’s composite watersheds are heavily forested, but not the Red River Basin, the single greatest contributing source of nutrient loads.

The Red River Basin is predominantly agricultural, containing many different land use types primarily related to the type of crop grown in a given year, or the type of pasture being managed. The nutrient export coefficients of various soil types can be used to estimate relative contributions of phosphorus and nitrogen from the land (including agricultural land), and their proportion of total nutrient loads within downstream water bodies. The coefficients in Table 2-2 were used towards estimating Lake Winnipeg’s “natural background” nutrient loads.

Land Use Category	TN (kg/ha/yr)	Range	TP (kg/ha/yr)	Range
Pasture	1.75	0.17 - 4.28	0.22	0.02 - 0.51
Cropland	3.15	0.30 - 6.70	0.65	0.03 - 1.10
Forest	1.68	0.23 - 3.93	0.12	0.01 - 0.38
Other - waterbodies, wetlands, urban areas, and barren land	4.0		0.20	

Table 2-2: Mean and range of TN and TP export coefficients (kg/ha/yr) for specific land uses.
Sources: Chambers and Dale 1997; Green and Turner 2002 in Bourne 2002:29

While there has been some criticism of this approach (Flaten 2003b), (specifically the reference data for various export coefficients and the reliance on generalized coefficient application across diverse watersheds, particularly relating to their variability of precipitation receipt) Bourne notes that:

Watershed nutrient loads are more difficult to quantify than direct effluent discharges because they are often more diffuse, highly variable, and intermittent. The load of nutrients exported from land to surface water depends on soil type, vegetation cover, and precipitation. The type of land use practices or activities also heavily influence the movement of nutrients from land to surface waters.

Rates of nutrient export can be lowered by the presence of riparian vegetation along stream channels and lake shores, while the development of drainage channels can have the opposite effect and result in increased nutrient export to surface waters. The amount of nutrient loading to land from atmospheric deposition and agricultural fertilizer and manure applications can also strongly influence the amount of nutrients that are available for export to surface waters.

[Bourne 2002:29-30]

Enhanced Drainage, Reduced Riparian Vegetation, and Precipitation Impacts

Bourne (2002) has noted that artificial drainage networks (typically to facilitate agricultural development) increase the natural rate at which nutrients are exported from the land to downstream waterways. Similarly, the loss of wetlands also amplifies these nutrient losses. Equally, losses of

riparian vegetation cause streambanks to become less stable, less able to retain nutrients, and more prone to erosion of nutrient-rich sediments.

These trends are echoed within the hydrologic connectivity literature (Section 2.4). Alexander notes that “land use changes or modifications to stream channels that increase the flow rates in headwater streams may heighten their influence on the chemical quality of downstream receiving waters” (2007:46). Wipfli (2007) also notes that different land uses and hydrologic management regimes such as: agricultural development and cultivation, forest harvesting, mining, road construction, urbanization, channelization flow regulation, irrigation, and reservoir creation all dramatically influence these natural processes, which influence downstream ecosystems.

It is interesting to note that the only existing Manitoba-based research directly contributing to understanding nutrient loads at the land-water interface within the province’s agricultural watersheds (South Tobacco Creek) has determined that “overall, nutrient loadings appear more responsive to the nature of the hydrological events rather than land use,” based on the observation that periods of higher loading do not correlate to the years when chemical fertilizer applications were the greatest (Glozier 2006:64). These findings are outlined in Table 2-3.

Year	Total Nitrogen	Total Dissolved N	Total Phosphorus	Total Dissolved P
	% of Applied Fertilizer			
1994	3.1	1.9	2.4	0.9
1995	7.6	4.6	6.4	2.1
1996	9.5	5.8	5.4	1.9
1997	10.6	5.8	5.4	1.9
1998	8.4	5.1	5.7	1.9
1999	3.3	2.0	2.6	0.7
2000	0.7	0.5	0.7	0.2
2001	8.8	4.9	7.2	2.3
Average	6.5	3.8	4.9	1.5

Table 2-3: Loadings of N and P at Miami, MB expressed as a percentage of fertilizer applied within the South Tobacco Creek minor watershed from 1994 to 2001. Source: Glozier 2006:64

However land-based contributions are important (if not from applied fertilizer). In seeking to understand this relationship, Glozier also notes that:

...the hydrologic conditions during spring melt did have a large influence on total nutrient and sediment loading. On average, a relatively small proportion of the annual loading is transported during the summer (May to October) period...The majority of the dissolved nutrient transport occurs with snow melt events.

Regarding the dissolved fractions, we observed low dissolved concentrations during base flow, higher dissolved P at the edge of field (under conventional tillage) than in the main stem, and the dissolved nutrient fraction peaking simultaneously with discharge. These observations, along with the rapid increase in dissolved concentration with longitudinal river distances, suggest that the source of dissolved nutrients may be largely land-based processes in contrast to the within-channel sediment source.

[Glozier 2006:68-69]

Streambank and Streambed Erosion

As noted by Bourne (2002), nutrients can be associated with sediment carried in downstream through Manitoba waterways. Variables such as stream velocity and its associated energy contribute to “scouring” of nutrient particles from streambanks and/or streambeds. These in turn, can be redistributed downstream where phosphorus and nitrogen can enter the water column. Citing Haygarth and Jarvis (1999), Flaten notes that eroded sediment or suspended particles containing phosphorus “release precipitated or adsorbed phosphorus because the concentrations of phosphorus in most water bodies is much lower than that in soil solution” (2003:14). The hydrologic connectivity literature also supports this, noting that headwater stream management projects which involve channelization, enhanced drainage, diversion, crossings, tile drainage, and the general use of culverts all result in substantial changes to the drainage regime of a watershed. These changes generally result in negative water quality impacts, in addition to aquatic habitat loss (Freeman 2007).

South Tobacco Creek research in Manitoba has reported that:

It became evident that a greater proportion of the nutrient and sediment load originated in the upper portion of the watershed and/or, that sediment and nutrients were lost from suspension in stream water between H-240 and Miami [mid-watershed and lower watershed monitoring stations]. Dissolved nutrients increased rapidly in the upper watershed and even began to decline in concentration before reaching Miami, while the particulates increased closer to the confluence of the north and south arms.

Some sediment and particulate nutrients may be deposited on the streambed between H-240 and Miami if the energy of the stream decreased (e.g. a change in slope and velocity) and dissolved nutrients may have sorbed to sediments in the stream, transformed to other forms (including gaseous forms that could be lost to the atmosphere), or used as a food source by plants or organisms in the stream.

Finally, in calculations of the proportion of total nutrient loadings for comparisons to larger downstream watersheds such as the Red River, the phosphorus load derived in STC was disproportionately high on a watershed basis while nitrogen load was proportional to the watershed area. Therefore, these small escarpment catchments play an important role in the overall loading to the larger river and lake ecosystems downstream and their dynamics should be examined and understood in more detail to understand the potential implications of land management practices to stream nutrient concentration and loading.

[Glozier 2006:69]

Ground Water Infiltration and Rural Residential Septic Sources

Bourne explains that “infiltration of ground water via the streambed often provides a majority of the base flow in some streams during periods of low flow such as fall and winter.” and that elevated levels of nitrogen can occur within groundwater, via “the downward leaching of nitrates and nitrites from animal manure and inorganic fertilizer applications, and leakage of municipal sewage lagoons and private septic systems” (2002:6).

Flaten (2003b) also notes that the transfer of particulate and/or dissolved phosphorus can occur via the flow of groundwater through contaminated soil. Organic phosphorus sources are particularly problematic. Flaten has also pointed to the potential nutrient loading contributions from groundwater and rural residential septic sources north of Winnipeg:

There are many possible explanations for the TP loading within this section of the Red River Basin. In-stream processes, such as groundwater recharge and bank erosion, non-point

sources from the densely developed area adjacent to this stretch of the river, especially leaky septic systems, and combined sewer overflows are all potential contributors. The identification of the sources of P in this section of river needs further investigation.

[Flaten 2003b:10]

2.3.5.2 Present Day Agriculture: Focusing on Phosphorus

Bourne (2002) identified two main agricultural sources of nutrients: animal manure and inorganic fertilizer. These are discussed below.

Natural/Organic Agricultural Fertilizer/Manure

The LWSB makes a clear case for addressing phosphorus loading as an initial priority for reducing Lake Winnipeg nutrient loading, primarily due to the prevalence of livestock manure application in Agri-Manitoba, and the fact that:

Currently, manure application rates in Manitoba are regulated based on crop nitrogen inputs alone. However, the ratio of phosphorus to nitrogen removed by crops is lower than the phosphorus to nitrogen ratio in manure. Therefore, when only the nitrogen content of the manure is considered when determining application rates, phosphorus is often applied at rates that exceed agronomic requirements. A build-up of phosphorus in the soil can lead to soil phosphorus saturation and the subsequent release of phosphorus when water travels through, or over, the soil.

[LWSB 2006:64]

Phosphorus has been widely recognized as the logical first priority in addressing eutrophication in water bodies downstream from predominantly agricultural land use areas, primarily due to the propensity for its dissolved form to transport easily from the land into water bodies, and the fact that its particulate form readily attaches sediment (Hively 2006, Flaten 2003, and Soranno 1995). In addition to understanding the eutrophication contributions of phosphorus itself, these facts also denote the importance of understanding the interrelated processes of water flow and soil erosion, both of which can be accentuated by agricultural development and associated upland drainage.

The LWSB (2006:64) cites several sources including Manitoba Food and Rural Initiatives data (Farm Practices Guidelines) in outlining the relative Manitoba phosphorus contributions to agricultural land from livestock manure generated by beef cattle and hogs (based on 25,000 tonnes/year of total manure phosphorus in 2001). Manure phosphorus excretion values are based on data presented by Flaten (2003b:23) and current provincial cattle herd sizes provided by the Canadian Pork Council and Statistics Canada.

The LWSB provides a misleading reference that “In Manitoba, “7.9 million hogs were placed on the market in 2005,” which actually refers to total hog production during that year, not the total number of hogs within the province at any particular time, which was actually 2,910,000 animals in 2005, 2,980,000 in 2006, and is currently 2,965,000 hogs (Statistics Canada 2007).

Based on the actual and standardized 2006 comparisons, these estimates suggest that:

- phosphorus generated from 2.965 million hogs in Manitoba represent an average daily contribution ranging from 14,825 kg/day and 115,635 kg/day of manure phosphorus to agricultural land;
- phosphorus generated from 1.7 million beef cattle in Manitoba represent an average daily contribution ranging between 88,400 kg/day and 210,800 kg/day of manure phosphorus to agricultural land;
- based on the 2001 calculations by Flaten (2003b: 21-23), it can be reasonably assumed that current manure phosphorus contributions to agricultural land in Manitoba are currently in the range of 20,346 tonnes/year for beef cattle and 7,909 tonnes/year for hogs, an overall increase of 3,255 tonnes/year of manure phosphorus beyond 2001 levels for these two sectors;
- Manure phosphorus from chickens and turkeys is not deemed to be as significant (3%); and
- while beef cattle manure was estimated to generate nearly 70% of total manure phosphorus generated by livestock with hogs supplying 27 % in 2001, recent growth in the hog sector appears to have been slightly outpaced by growth in the cattle sector (17% vs. 19%), suggesting the ratio of cattle:hog manure phosphorus contributions has not changed appreciably since 2001.

Flaten also notes that “the runoff from manured fields can contain significant amounts of dissolved phosphorus, particularly when manures have not been injected or incorporated into the soil following application.” Groundwater may also be contaminated through leaching of phosphorus (in either its particulate or dissolved forms). “High concentrations of P in soil, especially in the form of organic P, create the potential for significant leaching of P into groundwater (2003:14).

Assuming the accuracy of the Lake Winnipeg phosphorus loading data contained within the Lake Winnipeg Stewardship Board final report (2006), the vast major of these manure phosphorus contributions are utilized locally near their sources, in the form of crop production and/or other forms of plant uptake (i.e. by riparian vegetation).

As described by Flaten (2003), various factors determine the amount of phosphorus exported from agricultural lands to downstream water bodies via surface runoff and/or groundwater flow:

- water infiltration rates determined by soil texture/structure;
- precipitation intensity/duration;
- snowfall volumes and speed of melt;
- crop management types and vegetative cover;
- slope, proximity to watercourses, and riparian health

Chemical/Inorganic Agricultural Fertilizer

The application of inorganic fertilizer to agricultural lands provides a source of nutrients that may later be exported to surface water through rainfall or snowmelt (Bourne 2002). In describing global nutrient loading trends, Alexander also notes that:

Nitrogen in the environment has vastly increased in recent decades, largely associated with growing populations and associated land use from (1) creation of reactive nitrogen, via the Haber-Bosch process, for fertilizers and other industrial applications (2) cultivation of vast areas of crops that host nitrogen-fixing bacteria; and (3) fossil fuel burning and the

associated emissions and nitrogen deposition (Smil, 2001). Worldwide, human activities have more than doubled the amount of reactive N entering the environment (Vitousek et al., 1997; Galloway et al., 2004).

[Alexander 2007:43]

In terms of inorganic fertilizer usage in Manitoba, based on data from Korol and Rattray (2001, 1997), Flaten (2003b) notes that inorganic nitrogen use has grown by seven-fold since 1965. Phosphorus usage has more than doubled during the period (Chart 2-3).

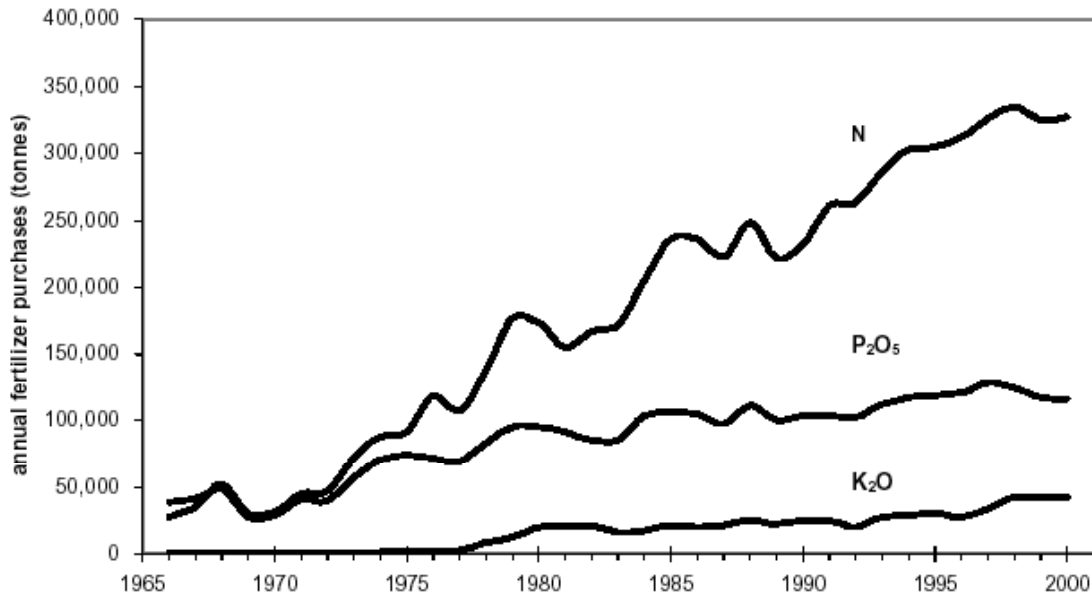


Chart 2-3: Annual fertilizer nutrient sales in Manitoba from 1965 to 2000 (adapted from Korol and Rattray 1997; Korol and Rattray 2001). Source: Flaten 2003b:18

The LWSB has also noted that approximately “85% of phosphorus applied to agricultural land comes from synthetic fertilizer,” which represents another important aspect of phosphorus loading for Lake Winnipeg (2006:65). It has also been noted that harvested crops were fairly effective in utilizing fertilizer-based phosphorus sources until the mid-1990s. Since then, fertilizer application rates have exceeded crop removals (Johnston and Roberts 2001 in Flaten 2003b).

In recommending the development of a “terrestrial nutrient budget for Agri-Manitoba,” the LWSB appears to have recognized (Recommendation 32.2) the importance of clarifying the relative phosphorus loading contributions from various sources within the agriculture sector, including beef cattle, hogs, and synthetic applications.

Addressing Manitoba Watershed Processes

As vital components of “present-day agriculture,” each of these agricultural phosphorus sources comprises a significant portion of the overall *Manitoba Watershed Processes* total of 2,500 tonnes/year entering Lake Winnipeg. Equally, “natural background and undefined sources” are suggested to represent an almost identical portion. Together, as *Manitoba Watershed Processes*, these interrelated components represent 32% of total Lake Winnipeg phosphorus loads and 67% of all Manitoba-based sources (LWSB 2006:25).

The dearth of long-term, Manitoba-based data surrounding farm field contributions suggests that real clarification regarding these relative nutrient contributions will be difficult. As such, the nutrient challenge should be most appropriately focused on finding the best means by which to reduce nutrient loads from within Lake Winnipeg's contributing drainage systems – at the watershed (or possibly subwatershed) level – towards addressing nutrient loads generated through *Manitoba Watershed Processes* as a whole, recognizing the reality that its natural background/undefined and agriculture components are interrelated, and that loading reductions via each and/or either pathway would be beneficial overall.

2.4 Hydrologic Connectivity of Headwater Streams

The accumulation of individual hydrological units forms the headwater streams for the rivers and lakes of a regional water system. These headwater streams represent “individual elements of integrated hydrological system” (Nadeau 2007:118) in which both upstream and downstream portions of individual watersheds are linked. Multiple watersheds in turn contribute to common receiving waters further downstream (e.g. rivers and lakes) and are also connected in this way, contributing to overall ecosystem integrity of regional water systems.

Hydrologic connectivity has been defined as “the water-mediated transport of matter, energy and organisms within or between elements of the hydrologic cycle” (Freeman 2007). Freeman estimates that headwater streams encompass more than two-thirds of total stream length within most watersheds, directly connecting upland and riparian areas to the rest of the drainage system. In the United States (excluding Alaska), headwater streams cover 53% (2,900,000 km) of total waterway distance, and of this amount, more than 50% of this distance includes intermittent and ephemeral streams which rely solely on precipitation for their flow (Nadeau 2007: 118).

Headwater catchments control the recharge of aquifers, movement of water, and amount of time that water spends in the system, the “residence time” of water within a landscape (Alexander 2007:41). The associated hydrological processes in these streams also control the type, timing, and distances traveled of material transported to downstream waters (including nutrients). Headwater streams can be characterized by the volume and type of organic matter they transport downstream, mixing with other materials carried by other contributing waterways into receiving water bodies such as rivers or lakes (Wipfli 2007).

Recent modeling research has concluded that:

...first order headwaters contribute approximately 70% of the mean-annual water volume and 65% of the nitrogen flux in second-order streams. The contributions to mean water volume and nitrogen flux decline only marginally to about 55% and 40% in fourth and higher-order rivers that include navigable waters in their tributaries. These results underscore the profound influence that headwater areas have on shaping downstream water quantity and water quality.

[Alexander 2007:41]

Figure 2-3 depicts this relationship, and the very significant nitrogen contributions of headwater streams to total loads downstream, which Alexander attributes to “the high density of headwater

streams and the high frequency of their connections to the channels of all higher order streams.” (2007:54). Alexander explains this as a defining characteristic of all dendritic river networks.

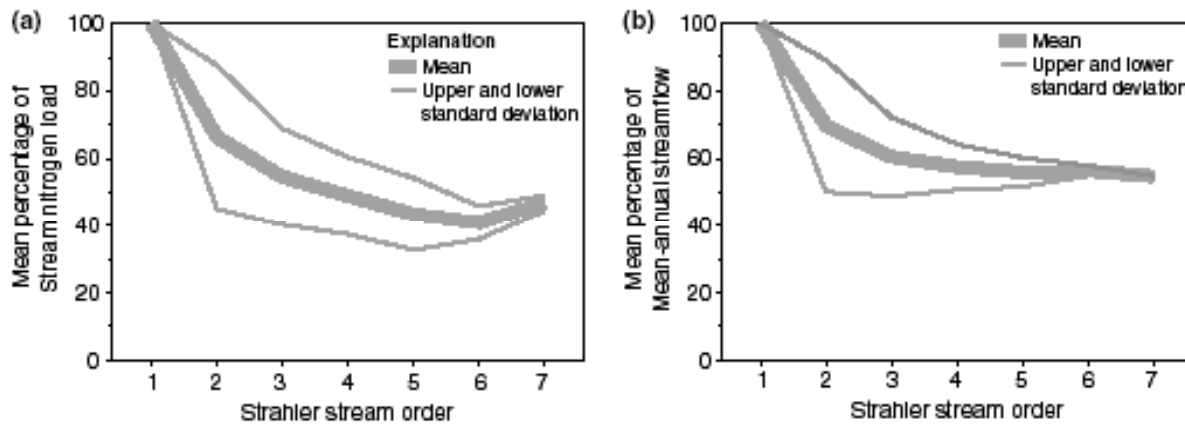


Figure 2-3: The percentage of the mean-annual load and streamflow in streams of the northeastern United States that originate in headwater catchments: a) nitrogen; b) streamflow. Source: Alexander 2007:54

The movement of material from small streams through a watershed to downstream water bodies is quantified in terms of relative rates, timing, and conversion processes (Wipfli 2007). Larger particles are converted into more easily transported smaller particles, while dissolved organic matter is converted into more useable larger particles for food chain consumers. Wipfli (2007) also notes that downstream water bodies are significantly influenced by headwater streams through hydrological and ecological processes. Anthropogenic alterations to natural systems cause changes downstream.

Alexander’s research (2007) into the downstream fate and influence of nitrogen in watersheds has been based on the fact that its reactive and mobility properties make it an effective surrogate in understanding many pollutants. Alexander notes that:

Once nitrogen is delivered to streams or rivers, the aquatic ecosystem itself plays a critical role in modifying the nitrogen (and other material) fluxes, via channel routing and instream processing. Stream channels have a natural dendritic design that plays an intrinsic role in transporting nitrogen and other pollutants from widely dispersed upstream sources and concentrating these materials in downstream waters.

Hyporheic zones of streams [stream channel and streambank sediments] also play a key role in nitrogen transformations (uptake and cycling) and permanent removal (i.e. denitrification) as nitrogen is exposed to reactive benthic surfaces during transport.

[Alexander 2007:44]

Increases in headwater stream peak flows are likely to reduce their natural uptake of nitrogen, thus increasing the distance (and concentration) of nitrogen transport downstream. Also, channelization of natural streams, resulting in the removal of natural pools and riffles, reduces the travel time of water moving downstream – simultaneously reducing natural nitrogen uptake by stream channel and streambank sediments (Alexander 2007). The development of artificial drainage systems can be expected to produce similar effects. The distribution of human and animal populations, land use, soil types, and vegetative cover all determine the concentrations, volume, and location of nitrogen loading to a stream and within a watershed (Boyer 2002).

It is important to note that riverine floodplains and riparian areas are critical locations for the denitrification process, particularly during floods, when increased water depths serve to improve nitrogen contacts with “microbially reactive floodplain sediments” (Alexander 2007:46). Similarly, wetlands have also been widely recognized for their ability to remove excess nutrients and improve downstream water quality (Newbold 2005).

Significant headwater stream modifications that reduce stream length tend to lower secondary productivity of rivers, which in turn affects aquatic life and wildlife that utilize the water resources (Freeman 2007). As noted by Meyer, “small streams differ widely in physical, chemical, and biotic attributes, thus providing habitats for a range of unique species” (2007:86). These attributes include such things as temperature ranges, available light, hydrologic regimes, water quality, substrate type, and food resources. The diversity of terrestrial and aquatic life across numerous headwater streams of a single watershed contributes to the biodiversity of the entire drainage system. (Meyer 2007).

Activities that modify or threaten these diverse headwater attributes in turn influence the downstream ecosystem. The ecological effects of altering headwater streams (and wetlands) in a watershed through enhanced drainage and increased peak flows are magnified by land uses that also increase runoff and nutrient loads to streams. The cumulative effects of these alterations typically result in increased downstream eutrophication and other negative ecological impacts.

Bourne (2002) and Glozier (2006) have also demonstrated the influential contributions of headwater streams in terms of their nutrient loads in Manitoba (Table 2-4).

River	Location	Area (km ²)	Total Nitrogen (kg/km ²)	Total Phosphorus (kg/km ²)
Red	Selkirk	127,000+153,000	258	39
Assiniboine	Headingley	153,000	89	15
Boyne	Carman	1325	74	7
Cypress	Bruxelles	815	69	11
Ochre	Ochre River	460	80	7
South Tobacco	Miami	76	290	70

Table 2-4: Average total N and P loadings in South Tobacco Creek between 1994 and 2001 relative to other Manitoba streams (adapted from Bourne et al. 2002). Source: Glozier 2006:60 with Assiniboine River Drainage data from ArcticNet (2007)

Citing Forrester (2004), Glozier notes that South Tobacco Creek is similar to other escarpmental streams, and its location along the Manitoba Escarpment contributes to its relatively high nutrient loads; “these small upland catchments likely play an important role in the overall loading to the larger river and lake ecosystems downstream, and their dynamics should be examined and understood in more detail” (2006:60).

2.5 Modeling Nutrient Load Reductions in Watersheds

Natural and anthropogenic watershed processes largely determine the potential for nutrient loading within downstream water bodies. By influencing these activities, it is possible to reduce and potentially reverse the impacts of elevated nutrients levels beyond healthy watershed nutrient limits.

Watershed modeling research has sought to better understand the cumulative contributions of relative nutrient sources and the efficacy of various institutional, expenditure, regulatory, and economic tools which policy-makers may utilize to influence the watershed activities. Some innovations in the area of watershed modeling and *Total Nutrient Management* experiences to date have been reported in the following areas and hydrologic levels.

Watershed Scale

The Rönneå Catchment is the pilot research watershed for the Swedish Water Management Research Program (VASTRA), located in the southern tip of the country and draining into Skölderviken Bay in the Jutland Strait. This 1,900 km² drainage system has been the focus of numerous long-term studies, including development of the HBV-NP model, a dynamic hydrologic model which has been refined to simulate Swedish landscapes and climatic conditions. Agricultural land use with the system represents 30% of total watershed area (Andersson 2005, Arheimer 2005).

In response to the EU Water Framework Directive, Sweden's efforts to reduce anthropogenic sources of eutrophication have resulted in national objectives focused on the reduction of nitrogen and phosphorus loads to each of its main river basins – by 30% and 20% respectively, by 2009. In support of these goals, substantial efforts have been devoted to integrated catchment modeling (Arheimer 2005).

The Rönneå Catchment was subdivided into 64 subwatershed units for HBV-NP calibration. Cumulative modeled subwatershed nutrient loads were compared with a total loading simulation for the entire Rönneå Catchment, yielding comparable results and likely applicability for the analysis of similar watersheds – at the watershed scale. Collection of more detailed data at the subwatershed level (e.g. soils, land use, point sources, and rural household loads) would be desirable for improving the understanding of nutrient behaviour within this particular system, although it may make the HBV-NP less applicable elsewhere, given the diversity of subwatershed systems (Andersson 2005).

Several nutrient reduction scenarios were tested by Arheimer (2005) using the HBV-NP model. These involved a variety of beneficial management practices (BMPs) and other interventions – focused on agricultural, rural households, wastewater treatment plants, and industrial loading sources. The most cost-effective scenario involved the construction of wetlands on 2% of all agricultural land, combined with improved rural household waste management (Arheimer 2005).

Subwatershed Scale

The Sugar Creek Watershed has been defined as one of the most impaired systems within the US State of Ohio. This 925 km² headwater system is the state's single largest contiguous watershed within the Ohio River system (Muskingum River). Given its apparent role in causing eutrophication and related water quality problems downstream, Sugar Creek (with 80% of its area in agricultural production) was targeted early for *Total Maximum Daily Load* planning and associated requirements for 60% reductions for both nitrogen and phosphorus contributed from all non-point loading sources (Prasad 2005).

At Sugar Creek, hydrologic data and nutrient loads have been analyzed using a digital elevation model (DEM) and a geographic information system (GIS) with the objective of understanding the relationship between landscape complexity and variation, along with anthropogenic land use and management. Several hydrologic parameters were defined for DEM application, with model results demonstrating a linkage between landscape features, agricultural production practices, and nutrient

loads. The introduction of more detailed land use and management data at the field level would improve model utility (Prasad 2005).

Minor Watershed Scale

The Yamada River Watershed is a 19km² system northeast of Tokyo, Japan. Agriculture is the dominant land use, and non-point sources from fertilizer and animal wastes have been previously identified as key non-point nutrient loading sources. A water quality tank model has been utilized to assess the effectiveness of five nitrogen reduction scenarios. These included: soil washing, the use of slow-release fertilizer, reducing fertilizer application rates, use of cover crops, and the reduction of animal wastes (Kato 2005). Table 2-5 outlines the scenario results.

Scenario	Explanation	% Change in N	Year Achieved	Comment
Soil Washing (via precip)	Increase model precip to 200mm+	Initial decrease followed by future increase	2021	N load ultimately increases due to increased runoff
Slow-Release Fertilizer	No limit set for soil accumulation in model	Initial decrease followed by future increase	2030	Overuse of fertilizer will eventually worsen water quality
Fertilizer Applic. Reduction	Modeled application reduced to 0	-20%	2040	Likely unrealistic
Cover Crop Transition	Assume crop export from watershed	-10%	2040	Cover crops only absorb topsoil N
Animal Waste Reduction	All waste removed from watershed	-70%	2040	Most significant modeled scenario

Table 2-5: Nitrogen reduction scenario results generated through a water quality tank model for the Yamada River Watershed. Source: Adapted from Kato 2005:26

Individual Hydrologic Unit/Farm Scale

The Soil Moisture Distribution and Routing (SMDR) model was developed for watershed analyses of upland, well-vegetated agricultural areas (Gérard-Marchant 2006), further described as follows:

The purpose of SMDR is to identify the location and evolution of variable source areas for overland flow generation and to estimate water fluxes to streams and groundwater. The SMDR is intended as a tool for planners or groups interested in watershed management. Therefore, it does not require extensive calibration and is designed to use data that are readily available in electronic form: i) a digital elevation map, ii) a soil type map and the associated table of soil hydrologic properties, iii) a land use and land cover map, and iv) weather data (temperature, precipitation and potential evapotranspiration).

[Gérard-Marchant 2006:246]

The SMDR has been applied extensively within a privately-farmed 164 ha agricultural watershed in upstate New York – to determine the effectiveness of BMP implementation in reducing non point source nutrient loading of New York City’s third largest water reservoir. It is one of the few hydrologic models that can accurately simulate “saturation-excess overland flow,” ...“which occurs when precipitation falls on saturated soil,” which is generally more difficult to model than “infiltration-excess overland flow” (Gérard-Marchant 2006:245).

Hively has demonstrated that the SMDR model accurately simulates actual total dissolved phosphorus loads as observed at the watershed outlet. Building on this, the SMDR has predicted

that total dissolved phosphorus loads from manure-treated soils were less than 10% of total watershed loads during two years of actual manure applications (1997-1998). However, these loads varied greatly in terms of daily loads, with certain days during April and May exceeding 90% of total watershed loads. These results are possibly explained by the fact that the farm operator was utilizing many BMPs, including no winter spreading of manure. However, the highest loads (>90%) were seen on April and May days when stored manure from the winter was spread, and local runoff was significant (Hively 2006).

It is appropriate to note that the first phase of a Watershed Evaluation of Beneficial Management Practices (WEBs) will be completed on 31 March 2008, at South Tobacco Creek in Manitoba.

Québec Whole Systems Research and Application

There has been substantial research progress and practical application in Québec – focused on both a “whole farm budget” for nutrients, as well as modeling the downstream mobility of phosphorus throughout sizable watersheds.

Pellerin (2006, 2006b) has conducted extensive work into the Mehlich-III soil phosphorus saturation index – on various soil types and various crops. This index appears to be a reliable indicator of phosphorus accumulation levels, “provided that soil texture is taken into account” (Pellerin 2006:721). Finer textured soils are prone to releasing more water-extractable phosphorus than soils which are more coarse. Lower phosphorus fertilization requirements for crops such as corn have been demonstrated within the finer soils (>300 g clay kg⁻¹), implying that corn can be fertilized at lower rates in these conditions, with no yield loss (Pellerin 2006b:908).

These and related findings support extensive cooperative efforts among Québec’s provincial departments responsible for agriculture and environment – in addition to the province’s association of pork producers. These organizations have been working together and sharing information in an attempt to reduce total nutrient loading, beginning at the farm level. The concepts and basic model information behind Québec’s *Whole-Farm Nutrient Budget* effort was adopted from Holland, based on similar efforts in Europe which have been in place for more than 20 years (Trudelle 2007).

Central to the *Whole-Farm Nutrient Budget* which hog farmers are encouraged to adopt is the understanding that:

Nutrients arrive on the farm (Inputs) in the form of purchased feed, fertilizer, and animals or as N fixed by legumes. It is desirable that these nutrients leave the farm as marketed products (Managed Outputs) such as animals or crops. Any imbalance between Input and Managed Outputs will either (1) be added to soil reserves (adding to future environmental risks), or (2) lost directly to the environment.

Excess N will be lost to the air as ammonia gas or to surface and groundwater as nitrate or ammonia. Excess P is commonly stored in the soil, contributing to soil P levels in excess of agronomic requirements. A high soil P level increases the potential for P movement to surface waters, contributing to eutrophication issues.

The purpose of the Whole-Farm Nutrient Budget is to estimate an individual farm’s nutrient balance by identifying the sources of nutrient inputs/outputs, providing an “environmental yardstick” for measuring the nutrient performance of an agricultural operation.

This balance measures ***nutrients that cross the border of the farm and is not concerned with nutrients recycled within the farm***. For example, homegrown crops fed to animals raised on your farm will not be considered because they do not cross the farm's boundary. Purchased feed products will be included because this nutrient Input crosses the boundary.

[CDAQ 2006:58]

The Québec research and application has substantially raised awareness regarding the importance of feed rations as a key element of the *Whole-Farm Nutrient Budget*. Given that 50-85% of the phosphorus contained within plant-based ration ingredients are in the form of phytate, and are not available for use by the pig – this portion of feed-based phosphorus is excreted directly in the form of manure. The recent availability of the commercially-produced phytase enzyme can result in 25-35% reduction in manure phosphorus (CDAQ 2006:12). There is now a major focus on fed-based phosphorus reductions in Québec (Trudell 2007).

Current research in Québec is now focusing on understanding and addressing phosphorus mobility at the watershed scale. With a focus on improving downstream water quality within Lake Champlain, on the Québec-Vermont boundary, BMP application modeling of Québec's Pike River watershed has demonstrated that 50% of this 630 km² system would require intensive application of sustainable cropping practices, combined with the conversion to permanent cover of the most vulnerable 10% of erosive lands within the watershed (Michaud 2007).

3 Understanding Upstream Watershed Management

Addressing the scientific challenges associated with a complete understanding how phosphorus and nitrogen loads enter Lake Winnipeg – while implementing institutional management responses to address these excess nutrient loads – requires an analysis framework which can logically and systematically accommodate the difficult fact that water (and nutrients) flow into Lake Winnipeg from a variety of sources.

These sources are located both within and beyond Manitoba’s boundaries and from a broad range of communities, individuals, industries, and natural background contributions.

The only appropriate framework within which these contributions may be usefully considered toward long-term management solutions is one which respects the fact water flows downstream – from the smallest hydrologic units – into successively larger catchments and river systems, until it reaches Lake Winnipeg.

3.1 Watershed Boundary Delineation and Hierarchies

Moving upstream using a nested hierarchy system, we note that each of these subregions and basins are subdivided into successively smaller subbasins, watersheds, subwatersheds, minor watersheds – down to the smallest measurable “hydrologic unit” of a few square kilometres or less.

In general terms “watershed” boundaries define the aerial extent of surface water drainage to a common point. The United States Geological Survey began developing a watershed classification system in the 1970s. This system has been refined over time, with recent contributions by the US Natural Resources Conservation Service (NRCS) resulting in a comprehensive watershed delineation system known as the Watershed Boundary Dataset, in which the largest six hydrologic unit levels exist.

The *Federal Standard for Delineation of Hydrologic Unit Boundaries* (NRCS 2004:12) notes “The selection and delineation of watersheds and subwatersheds requires good hydrologic judgment, and must be determined solely upon science-based hydrologic principles to assure a homogeneous national seamless digital data layer.” In addition:

Some earlier versions of watershed and subwatershed boundaries used administrative boundaries to define hydrologic units. Hydrologic unit boundaries must be determined solely upon hydrologic features. Do not use such administrative or political boundaries as county, state, national forest or other similar boundaries as criteria for defining a hydrologic unit boundary unless the administrative boundaries are coincident with topographic features that appropriately define the hydrologic unit. Although it may be impractical to make wholesale revisions to existing datasets that used administrative boundaries for delineating hydrologic units, these datasets would not be verified as meeting these standards until the hydrologic units are revised based on land surface, surface water flow and hydrologic features.

[NRCS 2004:13]

The Minnesota Department of Natural Resources (Minnesota DNR) has added two smaller units, denoting watersheds down to 100 acres in size (Minor Watershed, Individual Hydrologic Unit),

affording the possibility of detailed analysis down to the farm level (Minnesota DNR 2007). This level of watershed detail is critical when the central role played by individual decision-makers such as agricultural producers is to be considered as a key function within the Prairie Water Region. Table 1-1 has been adapted to the Prairies based on the NRCS and Minnesota protocols.

Table 3-1: Canadian Prairie Watershed Delineation
Source: Adapted from NRCS 2004 and Minnesota DNR 2007

Hydrologic Level	Classification	Approx. Area Limit	Example
1	Region	1,000,000 km ²	Lake Winnipeg/Prairies
2	Subregion	300,000 km ²	Red-Assiniboine System
3	Basin	150,000 km ²	Assiniboine River
4	Subbasin	30,000 km ²	Souris River
5	Watershed	3,000 km ²	Morris River
6	Subwatershed	1000 km ²	Tobacco Creek
7	Minor Watershed	100 km ²	South Tobacco Creek
8	Ind. Hydrologic Unit	10 km ²	On Farm Drainage

In flowing through these “watersheds,” the quality of this water is influenced by almost any impact related to land use and landscape change, contamination, and other forms of water use. Integrated Water Resources Management (IWRM) is the common term used today to reflect this paradigm.

3.2 Integrated Water Resources Management

The North Saskatchewan Watershed Alliance (2006) has suggested that “an integrated watershed management approach brings all the people living in a watershed together to make decisions that respect the watershed as a whole,” while:

Landowners, stakeholders, and municipalities cooperate with the federal and provincial governments to manage water resources. This is because watersheds cross jurisdictional boundaries and fractured, politicized management can break up ecosystems.

Local communities share in the responsibility, knowing their ‘downstream’ is somebody else’s ‘upstream’. What each user does in the watershed affects water quality for all users. This is especially important when we consider that the biggest problem in most watersheds is non-point source pollution – pollution that comes not from a single source like a factory or a treatment plant, but from thousands of small sources like homeowners fertilizing their lawns or motor oil washing off roads into storm drains.

An integrated watershed management approach also makes watersheds the focus for management, rather than just the water. When we protect and enhance the watershed as an ecosystem, we recognize the relationship between human needs, ecological processes, and water quality. The state of our water is intimately connected to the health of the land, the presence of diverse plant and animal species, and the choices we make about land use.

[North Saskatchewan Watershed Alliance 2006]

Ontario's watershed-based Conservation Authorities (Conservation Ontario) have developed one of the clearest watershed process descriptions available, as in Figure 3-1 below:

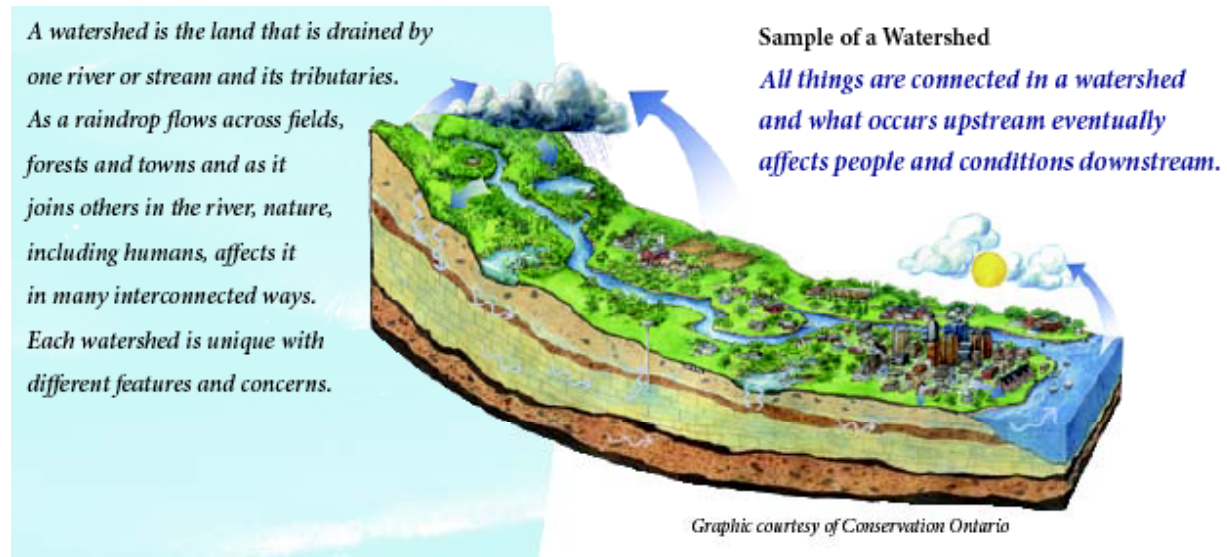


Figure 3-1: Description of a Watershed

Source: Conservation Ontario in Ausable Bayfield Maitland Valley Source Water Project 2007

Building on the hydrologic connectivity themes in Section 2.4, it is critical to understand the myriad interrelationships occurring within one watershed. It is equally important to grasp the concept that one watershed is “nested” within successively larger ones and that groups of smaller watersheds together comprise the drainage area of larger ones.

This concept is partially depicted within Figures 3-2 below, which simultaneously shows one watershed in southern Ontario (on the left) along with its composite “subwatersheds on the right.

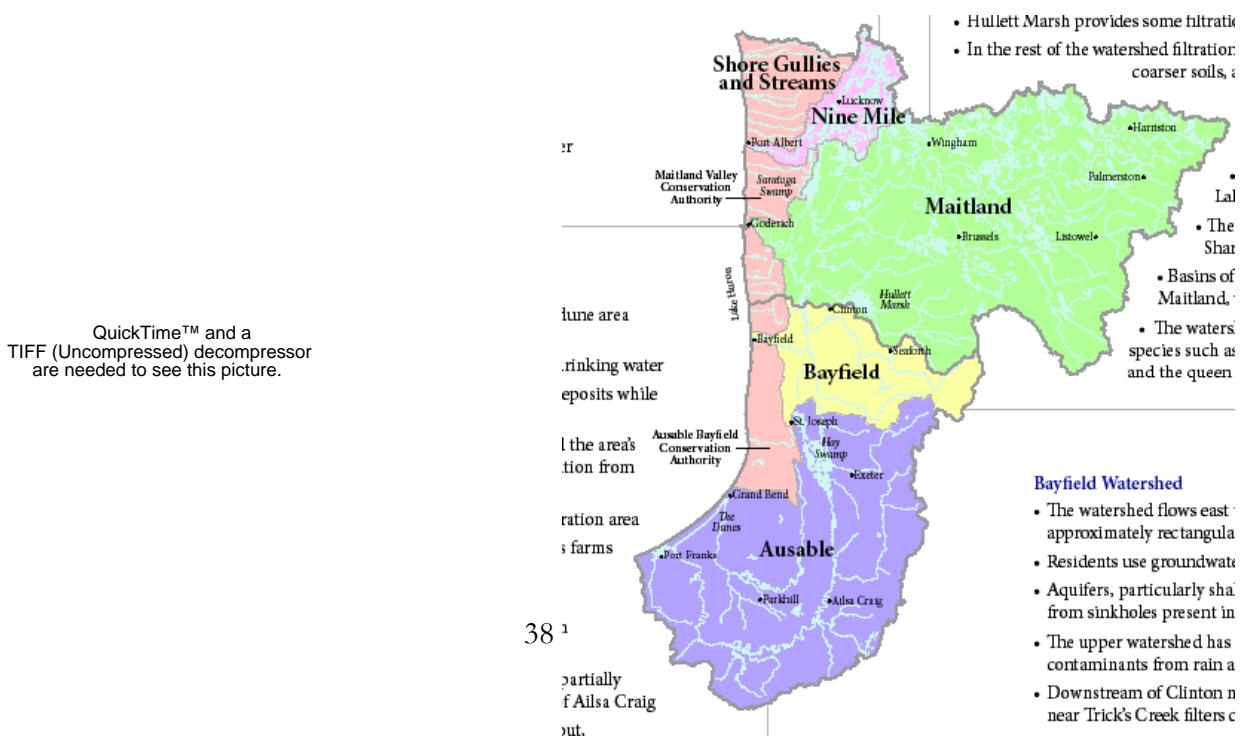


Figure 3-2: Watersheds and Subwatersheds
Source: Ausable Bayfield Maitland Valley Source Water Project 2007

Each of these subwatersheds are in turn comprised of smaller drainage areas or “minor watersheds.” This is depicted somewhat in Figure 3-3.

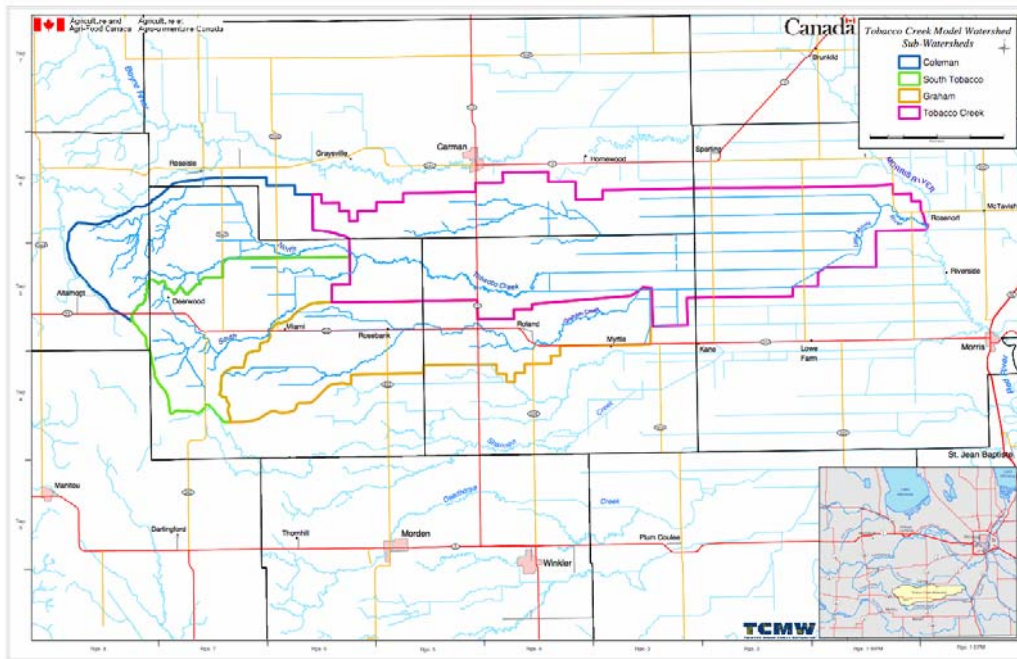


Figure 3-3: Subwatersheds and Minor Watersheds
Source: AAFC in Tobacco Creek Model Watershed 2004

Finally, these minor watersheds are in turn comprised of many “individual hydrologic units,” which can range in size from several hectares to several hundred hectares (Figure 3-4). Helpful video descriptions of how the individual landscape decisions affect overall watershed are available from the Conservation Technology Information Center (2005).

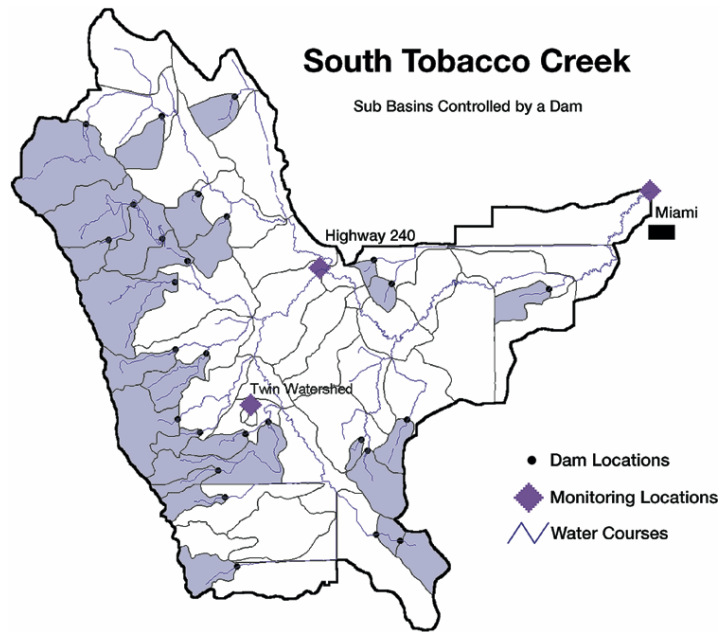


Figure 3-4: A Minor Watershed comprised of many Individual Hydrologic Units
 Source: AAFC in Tobacco Creek Model Watershed 2004

It has often been at the watershed (3000 km²) or subwatershed (1000 km²) level where significant populations thresholds have stimulated groups of people to form communities among which meaningful and manageable relationships and interconnections exist. As such, it seems that a focus on watersheds (or subwatersheds) may make the most sense when attempting to address the myriad challenges which are the focus of Integrated Water Resources Management (IWRM). We recognize of course that implementation of IWRM and its supporting concepts also represent opportunities to achieve broader societal goals. These goals are of regional interest to communities beyond the watershed or subwatershed level.

The Millennium Assessment (MA) has provided a critical IWRM policy insight. A future scenario consistent with improved *Ecological Goods and Services* (EG&S) provision is one in which, “regional watershed-scale ecosystems are the focus of political and economic activity. Local institutions are strengthened and local ecosystem management strategies are common; societies develop a strongly proactive approach to the management of ecosystems (MA 2005:8&50). MA Wetlands and Water Synthesis discussion related to MA Responses 15.5.3 and 15.5.4 suggests that:

The effective management of inland wetlands and water resources will require improved arrangements for river (or lake or aquifer) basin–scale management and integrated coastal zone management. The effective management of wetlands and water resources requires not only intersectoral coordination but also coordination across different jurisdictions. Actions taken upstream or upcurrent can have profound impacts on wetland resources downstream or down current. This in turn requires the use of integrated river basin (IRBM) or coastal zone management (ICZM). These integrated regional approaches to water resources management are recognized also as key strategy to contribute to the objectives of poverty alleviation.

To date, however, few efforts at implementing IRBM have actually succeeded in achieving social, economic, and environmental objectives simultaneously. One of the key lessons emerging

from ICZM experiences is that more integration per se does not guarantee better outcomes. Adopting an incremental approach—focusing on a few issues initially and then gradually addressing additional ones as capacity increases—is often more feasible and effective. In addition, these approaches can only succeed if appropriate institutional and governance arrangements are in place and, in particular, if the authority and resources of the management mechanism are consistent with their responsibilities.

[MA: Water and Wetlands Synthesis 2005:58]

There is a growing body of literature exploring the political challenges which appear to be limiting the complete and successful application of integrated watershed management some early work by Nelson and Weschler (1998) noted the importance of strong community involvement, clear institutional arrangements, experience in cross-sectoral coordination, and the incorporation of fiscal incentives as important factors.

Community involvement and meaningful public participation are recurring themes in watershed management (Gooch 2005, Carr and Wilkinson 2005, and Morris 2005), while Low and Ranhir (2005) have noted the importance of ongoing organizational change, strategic adjustment, information processing, and biodiversity protection as additional criteria. Several of these elements – in addition to recognition of the value of science-based policy experimentation – were characterized earlier by Lee and Lawrence (1986) and (Lee 1989) as *Adaptive Management*.

Agriculture-related water quality and quantity problems are a significant and growing concern across the Canadian Prairies (Schindler and Donahue 2006) – as is the perennial problem of declining on-farm income (Statistics Canada 2006). Any national, regional, or provincial efforts to address these issues should logically be integrated across traditional boundaries of private land ownership (MacFarlane 1998), while considering and respecting the perceptions held by all affected private landowners (Urban 2005).

Methods for evaluating water quality and water quantity trends are quite well developed at the watershed level and are still evolving (Deumlich 2005; Ramakar 2005; and Jain 2005).

3.3 Planning Within an IWRM Framework

In 2005, IISD conducted an extensive IWRM policy review of the Prairie Water Region. *Prairie Water Strategies: Innovations and Challenges in Strategic and Coordinated Action at the Provincial Level* (Swanson et al 2005) utilized an analytical framework based on the IWRM Management Cycle developed by the Global Water Partnership (GWP), which articulated IWRM as:

“a process which promotes the co-ordinated development and management of water, land and related resources in order to maximize the resultant economic, social welfare in an equitable manner without compromising the sustainability of vital ecosystems”¹

To be successful, the notion of integrated water resources management has also been described as “adaptive, evolving dynamically with changing conditions.”² Additionally, effective integrated water

¹ Jøneh-Clausen, Torkil (2004). “Integrated Water Resources Management (IWRM) and Water Efficiency Plans by 2005 - Why, what and how?” Global Water Partnership, Technical Committee.

resources management has been described as having three features which differentiate it from traditional resource-based management.³ First, it is more “bottom up” than “top-down” and thus emphasizes the building of capacity among local resource users. Second, integrated water resources management encourages cross-sectoral, interdisciplinary management of water resources. Finally, it encompasses management of other activities (e.g. land use) which affect water resources (i.e., it is focused on comprehensive solutions).

The GWP described integrated management for water resource management as a cyclic process of consisting of seven steps as illustrated in Figure 3-5: (1) establish status and overall goals; (2) build commitment to reform processes; (3) analyze gaps; (4) prepare strategy and action plan; (5) build commitment to actions; (6) implement frameworks (using a variety of institutional, expenditure, regulatory, and economic instruments) ; and (7) monitor and evaluate progress.

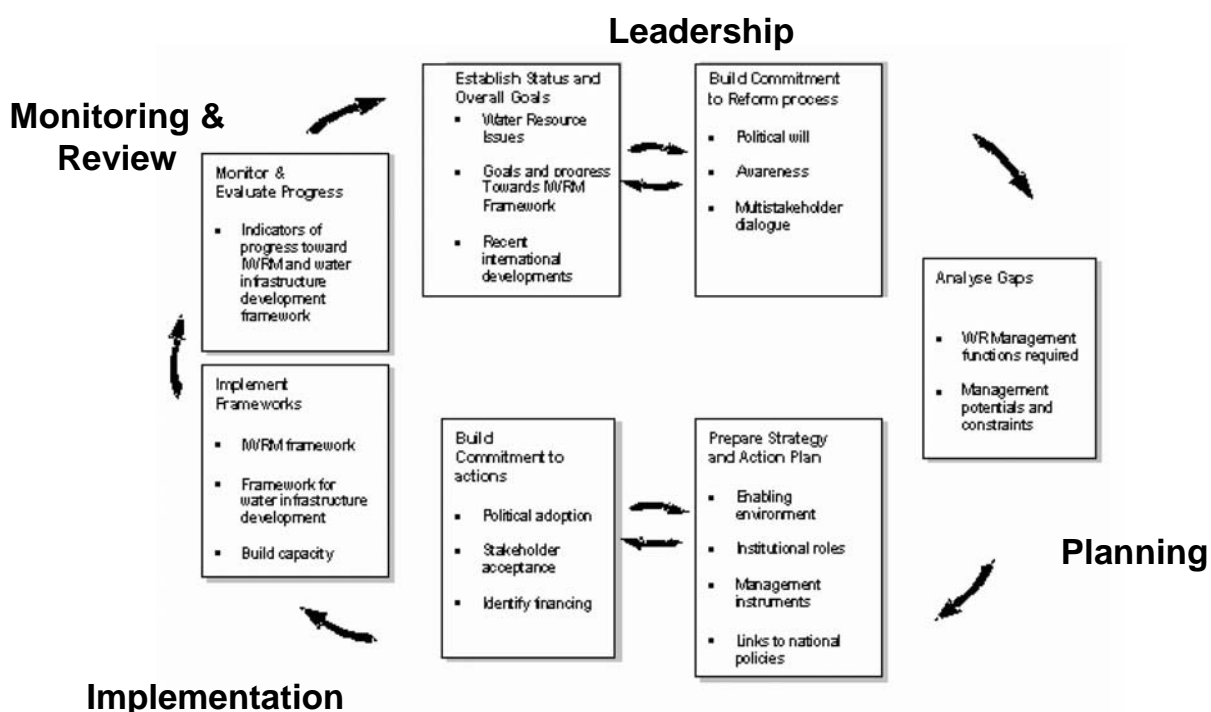


Figure 3-5. Global Water Partnership Integrated Water Resources Management Cycle
Source: (Jønch-Clausen 2004)

To study strategic and coordinated action for water resources at a provincial level, IISD simplified the above steps into four aspects as illustrated in Figure 3-6 (Swanson et al 2005). Included are:

Leadership (e.g., commitment through a strategy, focus through articulated goals and objectives);

Planning (e.g., departmental structure, inter-departmental planning, commitment to watershed planning and management) and **Multi-level Coordination and Participation** (e.g., coordination within a strategy process and among jurisdictions, and engagement of key stakeholders throughout the strategy process); and

² Global Development Research Center. 2005. Principles of Integrated Water Resources Management. Available: <http://www.gdrc.org/ucm/water/iwrm/1pager-01.html> (Accessed 18 July 2005).

³ From personal communication with Environment Canada – Water Policy Branch (2004).

Implementation (e.g., responsibility, financing and leveraging a mix of policy instruments);

Monitoring, Evaluation and Improvement (e.g., indicator monitoring, formal and informal evaluation and improvement processes).

In 2005, IISD used this analytical framework to prepare case studies on the water strategies of all three Prairie Provinces, and additionally, we applied this framework to interprovincial water management efforts – which led to a focus on the activities of Prairie Provinces Water Board. A detailed synthesis of these case studies was also conducted to identify common innovations and challenges in water strategies. Consideration of this synthesis then allowed for the identification of various shortcomings in the implementation of IWRM on the Canadian Prairies.⁴

3.3.1 IWRM's Key Monitoring Element

For the purposes of this project, the primary focus is on the fourth stage in the IWRM planning process (Figure 3-6): “Monitoring, Evaluation, and Improvement.” Development of a *Total Nutrient Loading Framework* for Manitoba should logically focus on improving Lake Winnipeg water quality as an ultimate goal, as much of the water flowing in and through the province influences this iconic water body. However, in order to make progress on Lake Winnipeg, its composite watersheds must become a central focus for action. Lake Winnipeg water quality will improve if the nutrient loads associated with its various drainage components (at various scales) can be reduced.

As noted in Section 2, relative nutrient contributions from many sources must be considered, particularly the interrelated elements of *Manitoba Watershed Processes* which include “natural background/undefined” and “present-day agriculture.” The importance of hydrologic connectivity – linking headwater streams to downstream water bodies – must also be incorporated, as does hydrologic scale. Also, the pivotal role of phosphorus and our current understanding of its export in particulate and dissolved form – from agricultural lands and through streambed and streambank erosion influence – must also be considered in some detail.

The ability to monitor water quality trends from individual hydrologic unit to the watershed, basin, or regional level is fundamental to understanding and/or utilizing the full potential of a *Total Nutrient Loading Framework*, if it were to be developed. In addition, this degree of monitoring would also serve to track the impacts of various IWRM initiatives, including those related to manure management.

Scientifically valid indicators of watershed health would need to be developed and monitored based on rigorous sampling protocols. Based on observed trends, progress toward nutrient loading reduction within each hydrologic unit could be observed, with determinations made as to whether this progress was due to various IWRM initiatives, or some other factors.

These evaluations would suggest how or if these IWRM actions could or should be improved over time, with a view toward continuous improvement. It is through this logic that an appropriate review of the relative nutrient contributions arising through hog production in Manitoba will be conducted in Task 2, assisting to understand the significance of these contributions, current review practices, and potential improvements.

⁴ Working versions of these case studies can be downloaded at http://www.iisd.org/natres/water/pwps_background.asp.

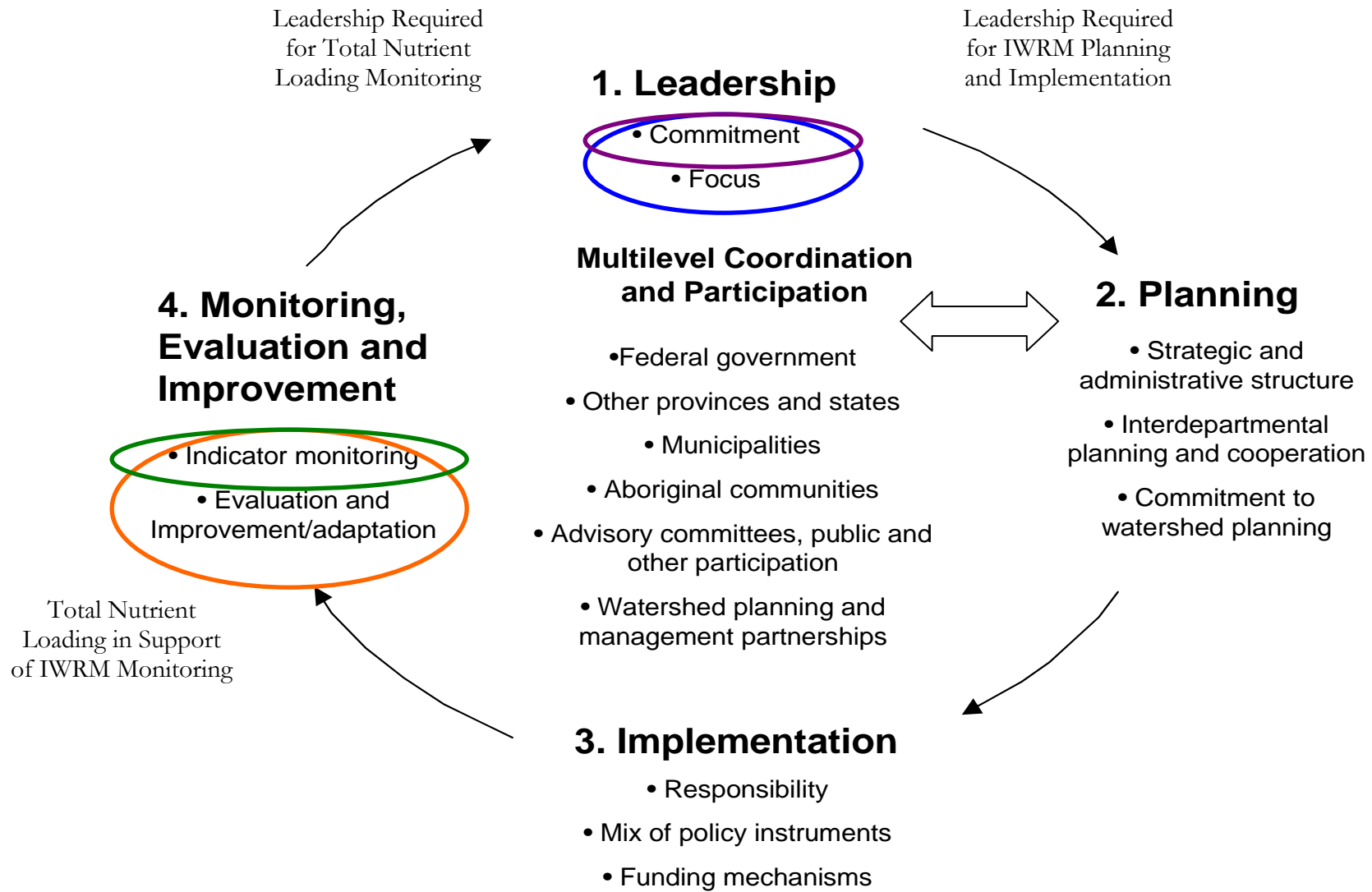


Figure 3-6: Total Nutrient Loading/Monitoring/Planning within the Context of IWRM
 Source: Adapted from Swanson et al (2005)

3.3.2 The Need for Leadership and Coordination

Figure 3-6 also denotes the centrality of “Leadership” in the IWRM planning cycle. Without leadership, there can be no effective IWRM Planning and Implementation or Monitoring, Evaluation, and Improvement. As such, without leadership there can be no *Total Nutrient Loading Framework* and no improvements in Lake Winnipeg water quality.

With regard to these issues, the Province of Manitoba is the most appropriate authority to provide the leadership which is required to address the province’s nutrient loading challenges. Given its authority over most aspects of natural resources management, Manitoba is responsible for most aspects of surface water management, agriculture, land use, environmental quality, and most municipal rural or urban issues related to municipalities.

Given these interrelated responsibilities, which are managed through the operations of numerous provincial government departments, effective provincial leadership would necessarily involve a high degree of interdepartmental planning, communications, and performance measurement. This is required to bring focus to the challenge of nutrient management, to harness the collective influence and full resources of government.

With the health of the province’s signature water body serving as the focus for provincial action, it would logically be accepted that any provincial efforts related to IWRM or development of a *Total Nutrient Loading Framework* would, by their very interrelated and interdepartmental nature, involve the highest possible level of support, from the highest offices of government. This is required to demonstrate the full commitment of government to the nutrient management challenge.

To be truly province-wide in nature, such provincial leadership would not be entrusted to only one department – but to several – under the direction of a designated Executive (Cabinet) Committee or perhaps the Premier, as the President of Executive Council. Such an approach would necessarily involve a high level of strategic coordination.

Leadership does take this form in other provinces where water issues have become major provincial priorities, such as in Alberta and Saskatchewan. In these provinces, provincial strategies related to safe drinking water and the implementation of watershed-based solutions have received the highest levels of Executive Council support, significant funding, and designations as *Cross-Government Strategies* for which several departments are accountable. These *Cross-Government Strategies* are also governed by clear guidelines for interdepartmental planning and reporting.

3.3.3 Policy Instruments to be Utilized

IWRM approaches, actions, and solutions need to be explored from the perspectives of federal and provincial governments, rural municipalities, landowners, production decision-makers, and society. This is essentially the same group of stakeholders, which are ideally also responsible for IWRM planning, implementation, and performance measurement. Key decisions are made by all participants, and their various land use and water-related decisions occurring within a particular watershed can result in downstream impacts of many types.

The development of a *Total Nutrient Loading Framework* is a logical approach to understanding, acting, and measuring progress toward reduced nutrient loads from the contributing watersheds of a downstream water body, these same composite watersheds, or general environmental quality.

Using sound science as a foundation, many social, economic and environmental impacts can be evaluated and adapted to – through a variety of policy instruments available to government, including: **institutional** instruments (internal education, strategies, policies, and procedures); **regulatory** (laws, regulations, and enforcement); **direct expenditure** (broad or targeted programs, education and awareness, and research and development); and **economic** instruments (taxes, fees, and incentives). Any policy instrument is comprised of two elements – design and implementation (IISD and TERI 2003).

3.3.3.1 Institutional Instruments

These include government strategies, new or revised institutional structures, and changes to policy and procedures of governments.

3.3.3.2 Regulatory Instruments

Regulations are one of the tools used by governments of all levels to restrict activities that are concerns for an entire sector, as an example, there are restrictions on how wastewater is managed.

3.3.3.3 Expenditure Instruments

Direct program expenditures designed to achieve particular goals may include the funding of various beneficial management practices (BMPs) to improve the condition of an area of concern. In the case of water quality, certain BMPs can reduce the flow of nutrients into a water body. BMP development and implementation should be based on encouraging individual decision makers to change their practices and remain with that particular practice after funding has expired.

3.3.3.4 Economic Instruments

These may involve incentives and/or changes to the tax system to encourage or reward individual decision-makers for changing the way they undertake certain activities.

4 Total Nutrient Loading on a Watershed Basis

Using the IWRM cycle and policy instruments discussed in Section 3, an effective *Total Nutrient Loading (TNL) Framework* can be developed. The following section outlines some of the critical components of the framework and the interactions between these components.

The development of a TNL Framework is driven by concerns regarding the health of a watershed, usually about a particular water resource. The design and implementation of such a framework is in itself the application of an *institutional* policy instrument. It would logically take the form of a “Total Nutrient Loading Strategy” centered on the institutionalization of watershed-based planning and management founded on the concepts of IWRM.

2.3.4 Understanding and Addressing Watershed Health

The ultimate focus of a the TNL Framework would be on understanding and addressing changes in the health of Manitoba’s watersheds, at various scales (from individual hydrologic units to basins, and regional water systems). The health of a water resource is of critical importance to the overall sustainability of a region, as it influences all social, environmental and economic factors.

In reality, the development of a TNL Framework represents one component of a comprehensive IWRM strategy. Other key elements would include the management of excess water flows during periods of intense precipitation, planning for drought, managing other contaminants, and improving overall water use efficiency in agriculture, industrial, and domestic settings.

However, with a present need to focus on nutrient reduction, several key aspects are required.

4.1.1.1 Research and Development

Research is fundamental component of a TNL Framework. Several questions still remain about nutrient movement from individual hydrologic units, through a watershed, and finally into a regional level water body. The research component assists in determining the maximum allowable levels of nutrients in the water, as well as monitoring nutrient levels in streams, rivers and lakes. The research activities usually lead to the development and recommendation of beneficial management practices. The results of the research influence watershed management decisions.

4.1.1.2 Current Watershed Nutrient Levels

Knowledge regarding current nutrient levels provides information necessary for the determination of which policy instruments may be most appropriate to improve downstream water quality. The various instruments used will either be: regulatory, expenditure, or economic in nature. In order to ensure that current nutrient levels (and their sources) are well understood, a significant degree of watershed monitoring will be required – from the individual hydrologic unit to the basin or regional level. It is likely that some of this required monitoring could be undertaken through the use of “representative watersheds” which have similar watershed and landscape features to others.

4.1.1.3 Maximum Healthy Nutrient Limits

An approximation of the maximum healthy nutrient limits for a watershed should be known for each contributing drainage system, as well as for downstream water bodies. Unfortunately, the

maximum healthy nutrient levels are not known in most cases, so precautionary limits should be used in the interim. While exact numbers may not be known, estimates can be used to promote nutrient reduction activities.

4.1.1.4 Incremental Changes in Nutrient Levels

The final element in the design of a TNL Framework would involve the ability to track incremental changes in nutrient loads within a watershed. These may result from either natural or anthropogenic sources, and they may be either positive or negative – in terms of their influence upon *Total Nutrient Loading* of the particular hydrologic unit being assessed.

Increased nutrient loads may occur in association with increased (or more intense) precipitation, which in turn causes increases in erosion and the movement of both dissolved and particulate nutrients downstream. These loads may also increase due to wastewater discharges from municipal sewage treatment facilities or agricultural runoff – among many other natural background or anthropogenic sources. As noted in Section 2, a substantial portion of these loads are in some way related to watershed processes, and a very significant portion of these arise from within Manitoba.

Nutrient loads within a watershed may also decrease due to natural factors, such as the type and mass of particular forms of riparian vegetation. The effective application of various policy instruments can also serve to reduce watershed nutrient loads. They may decrease in association with: various types of BMPs and effective watershed management coordinated by a conservation, farming, or other organization (expenditure instrument); specific regulations designed to reduce nutrient loading (regulatory instrument), or the use of particular incentives (economic instrument).

However, the primary focus of this project is centred on understanding how the individual decisions of private agricultural landowners (primarily hog producers) actually affect *Total Nutrient Loading*, and how these impacts can be reduced – through the application of various policy instruments. It is these incremental changes (and decisions) which are of the greatest interest at this time. The proposed TNL Framework will demonstrate how the impact of one additional hog barn development may theoretically be assessed in terms of its incremental impact on watershed health.

4.2 IWRM as a Planning Foundation

An effective TNL Framework would indicate to decision makers and other stakeholders concerned with the health of a water body, exactly what current levels of nutrient loading exist within a particular watershed – and how these would be affected by the incremental increase of one new hog barn. If this could be achieved, the planning process would benefit from the increased knowledge related to the various nutrient sources and removals.

Meanwhile, all stakeholders concerned about the health of a particular watershed would have greater knowledge regarding the incremental impact of one new hog barn on *Total Nutrient Loads*, offering greater clarity regarding this impact and greater comfort for those who are responsible for making the decision. Ideally, this would result in sustainable water resource management through an informed implementation process.

4.2.1 Hydrologic Scale Considerations

Nutrient loading throughout any drainage system can occur naturally and anthropogenically within each composite hydrological unit. The summation of these inputs determines *Total Nutrient Loading* levels for each particular watershed (at any scale). From a monitoring perspective, more data is typically better than less, and as such, measurements from each hydrological unit within the watershed hierarchy would be considered ideal. Realistically, however, this is not always possible or necessarily the most efficient method of measurement. Developing a TNL Framework requires an appropriate scale to be effective for a particular watershed system.

Selecting the appropriate scale for measurement requires an understanding of the regions hydrological classifications and the activities within each watershed and its sub-units. Table 4-1 outlines the hydrologic levels introduced in Section 3, their classification name, and the approximate area of each classification. Landscapes, climatic conditions, and anthropogenic activities tend to differ between each watershed and result in different nutrient loading potentials.

Table 4-1: Hydrologic Scales within a TNL Framework

Hydrologic Level	Classification	Approx. Area Limit
1	Region	1,000,000 km ²
2	Subregion	300,000 km ²
3	Basin	150,000 km ²
4	Subbasin	30,000 km ²
5	Watershed	3000 km ²
6	Subwatershed	1000 km ²
7	Minor Watershed	100 km ²
8	Ind. Hydrologic Unit	10 km ²

More detailed monitoring provides more information about nutrient sources, but at a watershed level this detail may not provide sufficient information to develop effective strategies for reducing nutrient loads. Total nutrient monitoring needs to be based on the value of information received and the costs associated with the measurement.

There are still un-answered questions relating to the source of nutrients that need to be further researched. Intensive monitoring and research are gradually increasing the available knowledge surrounding nutrient loading. With this research, the effectiveness of nutrient source and removal models are becoming more accurate, possibly resulting in the need for less physical monitoring within each watershed.

4.2.2 Depicting a Draft TNL Framework

The challenge for Manitoba now, is the delivery of an effective institutional framework for IWRM planning, implementation, and performance measurement. Choosing the right scale at which nutrient loads can be monitored and analyzed for effective nutrient loading reduction may differ across the province, based on such factors as soil types, topography, land use, and development intensity. IWRM is also largely a question of governance – of how individuals and groups can come together – to address mutual concerns related to the health of their watershed community.

Determining exactly when participating individuals, organizations, and communities are ready to collaborate and implement watershed-based solutions is a nascent research topic. The common drainage areas shared by communities should be *meaningful* to the people who live in them and use their resources. They should also be *manageable* so that local governance entities such as local municipalities, watershed districts, and other community stakeholders may in fact have significant influence in improving their condition. For these reasons, it seems most logical that the focus for IWRM (and TNL Loading) should be on the watershed or subwatershed level.

Figure 4.1 outlines the flow of nutrients through a water resource. This *Total Nutrient Loading Framework* demonstrates the cumulative effects of numerous individual hydrologic units, minor watersheds, and subwatersheds – supplying multiple watersheds and sub-basins – which in turn comprise larger basins and sub-regions – which ultimately drain into a major water body. Further details are included in Figure 4-2, with a focus on the watershed and subwatershed levels.

This framework also indicates how the use of various policy instruments such as regulation, direct expenditures (e.g. BMPs), and economic incentives could reduce the outflow of nutrients into the watershed and ultimately the sub-region.

The ability to assess the *Total Nutrient Loading* impact of one new hog barn development within any hydrologic unit could and should be the objective of an effective TNL Framework. An analysis of this aspect of the TNL Framework – exploring the current and a possible future decision-making process related to such a development (Proponent X), shall be the focus of our work Task 2.

Figure 4-1: Total Nutrient Loading Framework (Generalized)

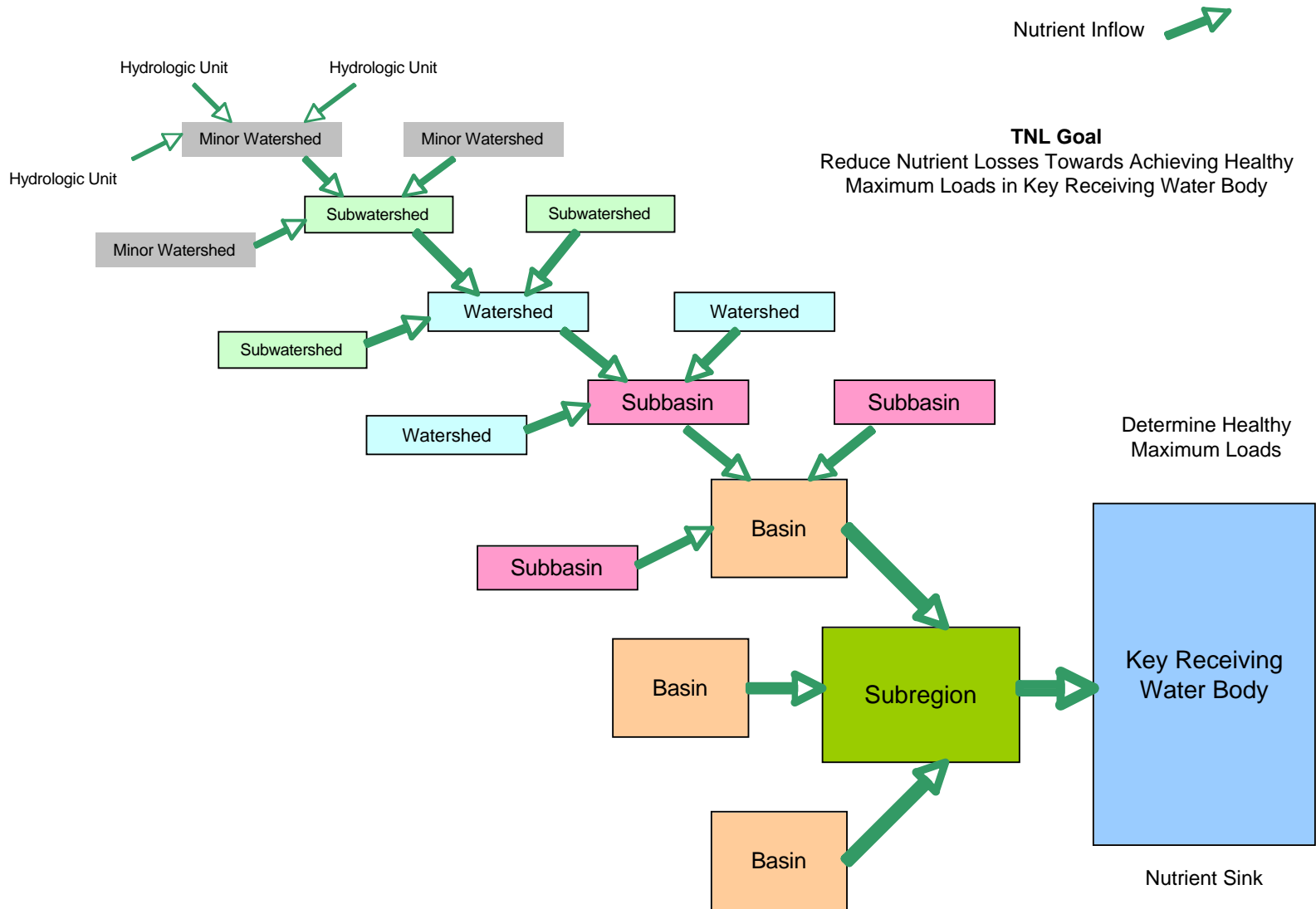
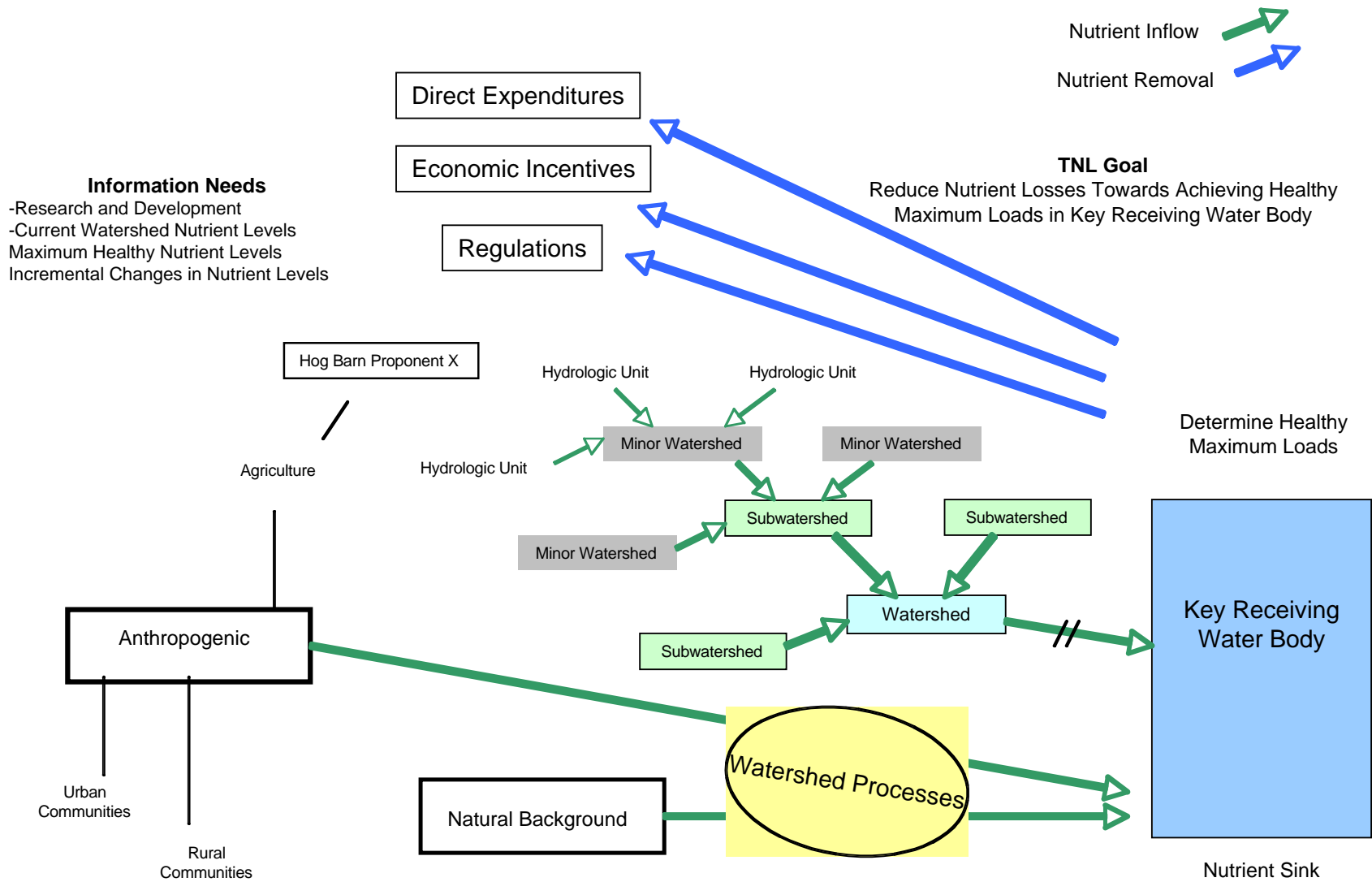


Figure 4-2: Total Nutrient Loading Framework (Watershed/Subwatershed Focus)



5 References

- Alexander, Richard B., Elizabeth W. Boyer, Richard A. Smith, Gregory E. Schwarz, and Richard B. Moore
2007 The Role of Headwater Streams in Downstream Water Quality. Theme Issue, "Hydrological Connectivity of Headwaters to Downstream Waters," *Journal of the American Water Resources Association* 43(1):41-59
- ArcticNet
2007 Assiniboine River at Headingley. Electronic Document, <http://www.r-arcticnet.sr.unh.edu/Points/P2917.html>, accessed 2 August 2007.
- Arheimer, Berit, Marianne Löwgren, Bodil Charlotta Pers, and Jörgen Rosberg
2005 Integrated Catchment Modeling for Nutrient Reduction: Scenarios Showing Impacts, Potential, and Costs of Measures. Theme Issue: "Towards More Integrated Water Resource Management," *Ambio* 34(7):513-520
- Arheimer, Berit, Johan Andréasson, Sofia Fogelberg, Holger Johnsson, B.C. Pers, and Kristian Persson
2005b Climate Change Impact on Water Quality: Model Results from Southern Sweden. Theme Issue: "Towards More Integrated Water Resource Management," *Ambio* 34(7):559-566.
- Ausable Bayfield Maitland Valley Source Water Protection Project
2007 Watershed Description. Electronic Document, <http://www.sourcewaterinfo.on.ca/content/spProject/watershedDescrip.php>, accessed 20 June 2007.
- Ausable Bayfield Maitland Valley Source Water Protection Project
2007 Watershed Map. Electronic Document, <http://www.sourcewaterinfo.on.ca/content/spProject/watershedMap.php>, accessed 20 June 2007.
- Berkes, Howard
2003 The Vision of John Wesley Powell. National Public Radio, 26 August. Electronic Document, <http://www.npr.org/programs/atc/features/2003/aug/water/part1.html>, accessed 15 February 2007.
- Blomquist, W. and E. Schlager
2005 Political Pitfalls of Integrated Watershed Management. *Society and Natural Resources* 18(2):101-117.
- Bourne, A., N. Armstrong, and G. Jones.
2002 A Preliminary Estimate of Total Nitrogen and Total Phosphorus Loading to Streams in Manitoba, Canada. Report No. 2002-04. Winnipeg: Manitoba Conservation, Water Quality Management Section.
- Boyer, Elizabeth W., Christine L. Goodale, Norbert A. Jaworski, and Robert W. Howarth.
2002 Anthropogenic Nitrogen Sources and Relationships to Riverine Nitrogen Export in the Northeastern USA. *Biogeochemistry* 57/58:137-169.
- Carr, A. and R. Wilkinson
2005 Beyond Participation: Boundary Organizations as a New Space for Farmers and Scientists to Interact. *Society and Natural Resources* 18(3):255-265.

- CDAQ: Conseil Pour le Développement de l'Agriculture du Québec (Agriculture, Pêcheries et Alimentation Québec – Fédération des Producteurs de Porcs du Québec).
2006 The Feed Balance Sheet in Pig Production. Technical Guide – March 2006. Québec: CDAQ.
- Coastal Environmental/PBS&J Inc.
1998 Lake Tarpon Drainage Basin Management Plan. Prepared for Pinellas County BOCC. Electronic Document, (<http://www.laketarpon.org/final/plan2.htm#plan2.2>, accessed 17 July 2007).
- Conservation Technology Information Center
2005 What is a Watershed? Electronic Document,
http://www.conservationinformation.org/?action=learningcenter_kyw_whatisawatershed, accessed 20 June 2007.
- Crossette, George
1970 Selected Prose of John Wesley Powell. Boston: David R. Godine. Electronic Document,
<http://www.csua.berkeley.edu/~cda/powell.html>, accessed 24 March 2007.
- Cunningham, William P., Mary Ann Cunningham, and Barbara Woodworth Saigo
2007 Environmental Science: A Global Concern. New York: McGraw Hill.
- Debuys, William
1999 Saint Contrary: John Wesley Powell. High Country News, 12 April. Electronic Document,
http://www.hcn.org/servlets/hcn.Article?article_id=4945, accessed 17 February 2007.
- Deumlich, D., W. Mioduszewski, I. Kajewski, M. Tippl, and R. Dannowski
2005 GIS-based Risk Assessment for Identifying Source Areas of Non-point Nutrient Emissions by Water Erosion (Odra Basin and Sub-catchment Uecker). Archives of Agronomy and Soil Science 51(4):447-458.
- Flaten, Don
2003 The Risk of Phosphorus Transfer to Water from Manure Application onto Agricultural Land. Paper presented at the 46th Annual Meeting of the Manitoba Society of Soil Science, Winnipeg, January 20-21.
- Flaten, D., K. Snelgrove, K. Halket, I. Buckley, G. Penn, W. Akinremi, B. Wiebe, and E. Tyrchniewicz
2003b Acceptable Phosphorus Concentrations in Soils and Impact on the Risk of Phosphorus Transfer from Manure Amended Soils to Surface Water. Phase 1 Report. Winnipeg: Manitoba Agriculture and Rural Initiatives, Manitoba Livestock Manure Management Initiative.
- Flores, Dan
2003 Image Credit
- Foster, N.W., F.D. Beall, and D.P. Kreutzweiser
2005 The Role of Forests in Regulating Water: The Turkey Lakes Watershed Case Study. The Forestry Chronicle 81(1):142-148.
- Freeman, Mary C., Catherine M. Pringle, and C. Rhett Jackson
2007 Hydrologic Connectivity and the Contribution of Stream Headwaters to Ecological Integrity at Regional Scales. Theme Issue, "Hydrological Connectivity of Headwaters to Downstream Waters," Journal of the American Water Resources Association 43(1):5-14.

- Gérard-Marchant, P., W.D. Hively, and T.S. Steenhuis
 2006 Distributed Hydrological Modelling of Total Dissolved Phosphorus Transport in an Agricultural Landscape, Part 1: Distributed Runoff Generation. *Hydrology and Earth Science Systems* 10:245-261.
- Glozier, Nancy E., Jane A. Elliott, Bruce Holliday, Jim Yarotski, and Brook Harker.
 2006 *Water Quality Characteristics and Trends in a Small Agricultural Watershed: South Tobacco Creek, Manitoba, 1992-2001*. Saskatoon: Agriculture and Agri-Food Canada, Environment Canada.
- Gooch, M.
 2005 Voices of the Volunteers: an Exploration of the Experiences of Catchment Volunteers in Coastal Queensland, Australia. *Local Environment* 10(1):5-19.
- Harper, Charles L.
 2004 *Environment and Society: Human Perspectives on Environmental Issues*. Upper Saddle River, NJ: Pearson Prentice Hall.
- Heindl, L.A.
 1972 Watersheds in Transition: Quo Vadis? *In* Csallany, S. et al eds. *Proceedings of a Symposium on Watersheds in Transition*. American Water Resources Association, Fort Collins, CO, p. 3-5.
- Hengeveld, Henry
 2006 *CO2/Climate Report, 2003-2005 Science Review: A Synthesis of New Research Developments*, Science and Technology Branch, Environment Canada.
- Hively, W.D., P. Gérard-Marchant, and T.S. Steenhuis
 2006 Distributed Hydrological Modeling of Total Dissolved Phosphorus Transport in an Agricultural Landscape, Part II: Dissolved Phosphorus Transport. *Hydrology and Earth System Sciences* 10:263-276.
- Imperial, M.
 2005 Using Collaboration as a Governance Strategy – Lessons from Six Watershed Management Programs. *Administration and Society* 37(3):281-320.
- IISD (International Institute for Sustainable Development) and TERI (The Energy and Resources Institute)
 2003 *A Framework for Energy Sustainability Assessment: The Energy Sustainability Gauge*. Winnipeg and New Delhi: IISD and TERI. Electronic Document, http://www.teriin.org/ee/gbr/fesa/fesa_report.htm, accessed 20 June 2007.
- Jain, M., U. Kothyari, and K. Raju
 2005 GIS-based Model for Soil Erosion and Rate of Sediment Outflow from Catchments. *Journal of Hydraulic Engineering* 131(9):755-769.
- Jøneh-Clausen, Torkil
 2004 *Integrated Water Resources Management (IWRM) and Water Efficiency Plans by 2005 - Why, what and how??* Global Water Partnership, Technical Committee.
- Kato, Tasuko
 2005 Development of a Water Quality Tank Model Classified by Land Use for Nitrogen Load Reduction Scenarios. *Paddy Water Environments* 3:21-27.

Lake Winnipeg Stewardship Board

2006 Reducing Nutrient Loading to Lake Winnipeg – Our Collective Responsibility and Commitment to Action: Final Report to the Minister. Winnipeg: Manitoba Water Stewardship, Lake Winnipeg Stewardship Board.

Lake Winnipeg Stewardship Board

2005 Our Collective Responsibility – Reducing Nutrient Loading to Lake Winnipeg: An Interim Report to the Minister. Winnipeg: Manitoba Water Stewardship, Lake Winnipeg Stewardship Board.

Lake Winnipeg Stewardship Board

2005b Report on Public Discussions – July 2005: Public Responses to the Lake Winnipeg Stewardship Board's February 2005 Interim Report. Winnipeg: Manitoba Water Stewardship, Lake Winnipeg Stewardship Board.

Lee, K. and J. Lawrence

1986 Adaptive Management: Learning from the Columbia River Basin Fish and Wildlife Program. *Environmental Law* 16:431-60.

Lee, Kai

1989 The Mighty Columbia: Experimenting with Sustainability. *Environment* 31(6):6-11, 30-33.

Low, S. and T. Ranhir

2005 Watershed Management, Structural Characteristics, Information Processing, and Cooperative Strategies in Conservation Organizations. *Journal of Soil and Water Conservation* 60(6):281-287.

Mallin, Michael A, Virginia L. Johnson, Scott H. Ensign, and Tara A. MacPherson

2006 Factors Contributing to Hypoxia in Rivers, Lakes, and Streams. Theme Issue, "History and Current Status of Eutrophication in Freshwater and Marine Ecosystems," *Limnology and Oceanography* 51(1, part 2):690-701.

MacFarlane, R.

1998 Implementing Agri-environment Policy: A Landscape Ecology Perspective. *Journal of Environmental Planning and Management* 41(5):575-596.

Manitoba Conservation

2006 Terms of Reference: Clean Environment Commission Investigation into Hog Production in Manitoba, Letter from Minister of Conservation, 8 November.

Manitoba Government

2007 News Release: "Lake Winnipeg Stewardship Board Receives Expanded Mandate: Melnick,; 14 February. Electronic Document, <http://www.lakewinnipeg.org/web/content.shtml?pfl=public/downloads.param&page=000101&op9.rf1=000101>, accessed 15 June 2007.

Manitoba Government

2006 News Releases: "Provincial Water Plan Referred to CEC for Public Input and Review," "Manitoba Announces Further Action on Water Protection Plan," and "Government Addresses CEC Recommendation to Review Hog Industry," 8 November. Electronic Documents, http://www.gov.mb.ca/waterstewardship/whats_new/2006.html, accessed 15 June 2007.

Manitoba Phosphorus Expert Committee

2006 Recommendations for Regulating Phosphorus from Livestock Operations in Manitoba: Final Report to the Minister. Winnipeg: Manitoba Conservation, Manitoba Phosphorus Expert Committee. Electronic Document, <http://www.gov.mb.ca/conservation/envprogrms/livestock/>, accessed 22 June 2007.

Manitoba Water Stewardship

2006 Issues and Options Arising from the Initial Consultation on Water Quality Management Zones for Nutrients. Winnipeg: Manitoba Water Stewardship, Water Science and Management Branch.

Manitoba Water Stewardship and Manitoba Conservation

2006 Report on Public Consultations: Proposed Regulation Defining Water Quality Management Zones for Nutrients and Proposed Amendments to the Livestock Manure and Mortalities Management Regulation. Winnipeg: Manitoba Water Stewardship and Manitoba Conservation.

Meyer, Judy L., David L. Strayer, J. Bruce Wallace, Sue L. Eggert, G.S. Helfman, and N.E. Leonard

2007 The Contribution of Headwater Streams to Biodiversity in River Networks. Theme Issue, "Hydrological Connectivity of Headwaters to Downstream Waters," *Journal of the American Water Resources Association* 43(1):86-103.

Michaud, A.R., I Beaudin, J. Deslandes, F. Bonn, and C.A. Madramootoo.

2007 SWAT-Predicted Influence of Different Landscape and Cropping System Alterations on Phosphorus Mobility within the Pike River Watershed of Southwestern Québec. *Canadian Journal of Soil Science* 87:329-344.

Millennium Ecosystem Assessment

2005 Ecosystems and Human Well-being: Wetlands and Water. Electronic Document, <http://www.maweb.org/en/index.aspx>, accessed 15 February 2007.

Minnesota Department of Natural Resources

2007 History of Watershed Delineation. Electronic Document, http://www.dnr.state.mn.us/watersheds/history_standards.html, accessed 20 February 2007.

Morris, C. and R. Morris

2005 The Ythan Project: A Case Study on Improving Catchment Management through Community Involvement. *Journal of Environmental Planning and Management* 48(3):413-429.

Nadeau, Tracie-Lynn and Mark Cable Rains

2007 Hydrological Connectivity Between Headwater Streams and Downstream Waters: How Science Can Inform Policy. Theme Issue, "Hydrological Connectivity of Headwaters to Downstream Waters," *Journal of the American Water Resources Association* 43(1):118-133.

Nakamura, F. and Y.S. Ahn

2007 Landscape Restoration: A Case Practice of Kushiro Mire, Hokkaido. *In Landscape Ecological Applications in Man-Influenced Areas: Linking Man and Nature Systems*, S.-K. Hong, N. Nakagoshi, B.J. Fu, and Y. Morimoto, eds. p. 209-233. Netherlands: Springer.

Natural Resources Conservation Service

2004 Federal Standards for Delineation of Hydrologic Unit Boundaries: Version 2.0. Electronic Document, <http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/>, accessed 20 February 2007.

Nelson, L. and L. Weschler

1998 Institutional Readiness for Integrated Watershed Management: The Case of the Maumee River. *Social Sciences Journal* 35(4):565-576.

Newbold, Stephen C.

2005 A Combined Hydrologic Simulation and Landscape Design Model to Prioritize Sites for Wetland Restoration. *Environmental Modeling and Assessment* 10:251-263.

North Saskatchewan Watershed Alliance

2006 Community Watershed Toolkit. Electronic Document, http://www.nswa.ab.ca/publications_watershedtoolkit.html, accessed 15 June 2007.

North/South Consultants Inc.

2006 Literature Review Related to Setting Nutrient Objectives for Lake Winnipeg: A Report Prepared for Manitoba Water Stewardship. Winnipeg: North/South Consultants Inc.

Paerl, Hans W.

2006 Assessing and Managing Nutrient-Enhanced Eutrophication in Estuarine and Coastal Waters: Interactive effects of Human and Climatic Perturbations. *Ecological Engineering* 26:40-54.

Pellerin, Annie, Léon-Étienne Parent, Josée Fortin, Catherine Tremblay, Lotfi Khairi, and Marcel Giroux

2006 Environmental Mehlich-III Soil Phosphorus Saturation Indices for Québec Acid to Near Neutral Mineral Soils Varying in Texture and Genesis. *Canadian Journal of Soil Science* 86:711-723.

Pellerin, Annie, Léon-Étienne Parent, Catherine Tremblay, Josée Fortin, Gilles Tremblay, Christine P. Landry, and Lotfi Khairi

2006b Agri-Environmental Models Using Mehlich-III Soils Phosphorus Saturation Index for Corn in Québec. *Canadian Journal of Soil Science* 86:897-910.

Pers, Bodil Charlotta

2005 Modeling in Response of Eutrophication Control Measures in a Swedish Lake. Theme Issue: "Towards More Integrated Water Resource Management," *Ambio* 34(7):552-558.

Prasad, V. Krishna, A. Ortiz, B. Stinner, D. McCartney, J. Parker, D. Hudgens, C. Hoy, and R. Moore

2005 Exploring the Relationship between Hydrologic Parameters and Nutrient Loads Using Digital Elevation Model and GIS – A Case Study from Sugar Creek Headwaters, Ohio, USA. *Environmental Monitoring and Assessment* 110:141-169.

Ramakar, J., C. Ojha, and K. Bhatia

2005 Estimating Nutrient Outflow from Agricultural Watersheds to the River Kali in India. *Journal of Environmental Engineering* 131(12):1706-1715.

Saskatchewan Agrivision Corporation

2007 Calling It Like It Is: Developing a National Grains Strategy – The Prairies, Phase 1: Grains Strategies Project, Electronic Document, <http://www.agrivision.ca/>, accessed 14 June 2007.

Schindler, D.W.

2006 Recent Advances in the Understanding and Management of Eutrophication. Theme Issue, "History and Current Status of Eutrophication in Freshwater and Marine Ecosystems," *Limnology and Oceanography* 51(1, part 2):356-363.

Schindler, D.W. and W. Donahue

2006 An Impending Water Crisis in Canada's Western Prairie Provinces. *Proceedings of the National Academy of Sciences of the United States of America* 103(19):7210-7216.

Sidle, Roy C., Makoto Tani, and Alan D. Ziegler

2006 Catchment Processes in Southeast Asia: Atmospheric, Hydrologic, Erosion, Nutrient Cycling, and Management Effects. *Forest Ecology and Management* 224:1-4.

Smith, Val H., Samantha B. Joye, and Robert W. Howarth

2006 Eutrophication of Freshwater and Marine Ecosystems. Theme Issue, "History and Current Status of Eutrophication in Freshwater and Marine Ecosystems," *Limnology and Oceanography* 51(1, part 2):351-355.

Soranno, P.A., S.L. Hubler, S.R. Carpenter, and R.C. Lathrop

1996 Phosphorus Loads to Surface Waters: A Simple Model to Account for Spatial Pattern of Land Use. *Ecological Applications* 6(3):865-878.

Swanson, Darren, Stephan Barg, Henry Venema, and Bryan Osborne

2005 Prairie Water Strategies: Innovations and Challenges in Strategic and Coordinated Action at the Provincial Level. Electronic Document, http://www.iisd.org/natres/water/pwps_background.asp, accessed 2 March 2007.

Statistics Canada

2007 Hog Statistics Catalogue No. 23-010-XIE Volume 6(3). Ottawa, Statistics Canada

Statistics Canada

2006 Farm Net Income Forecasts

Tobacco Creek Model Watershed

2004 People, Landscape, Planning, Action: Water Strategy Blueprint: Roland, MB, TCMW, Watershed Management and Research Plan. Electronic Document, <http://www.tobaccocreek.com/proposal.php>, accessed 20 June 2007.

Trudelle, Marc.

2007 Personal Communication. Soils Specialist; Environmental Services, Livestock Section: Manitoba Conservation. 8 August 2007.

Urban, M.

2005 Values and Ethical Beliefs Regarding Agricultural Drainage in Central Illinois, USA. *Society and Natural Resources* 18(2):173-189.

Wipfli, Mark S., John S. Richardson, and Robert J. Naiman

2007 Ecological Linkages between Headwaters and Downstream Ecosystems: Transport of Organic Matter, Invertebrates, and Wood Down Headwater Channels. Theme Issue, "Hydrological Connectivity of Headwaters to Downstream Waters," *Journal of the American Water Resources Association* 43(1):72-85.

Yusop, Zulkifli, Ian Douglas, and Abdul Rahim Nik

2006 Export of Dissolved and Undissolved Nutrients from Forested Catchments in Peninsular Malaysia. *Forest Ecology and Management* 224:26-44.

Research in Support of the Manitoba Clean Environment Commission's Hog Production Industry Review

Task 2 – Policy/Process Review – Conclusions/Recommendations

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1 Introduction

This report advances discussion surrounding the *Total Nutrient Loading Framework* developed in Task 1, in support of a practical understanding of current policy and decision-making processes related to the development of new hog barn operations in Manitoba.

1.1 The CEC Review

On 8 November 2006, the Minister of Manitoba Conservation requested that the Manitoba Clean Environment Commission (CEC) to “conduct a review and produce a report on the environmental sustainability” of the hog industry in Manitoba (Manitoba Conservation 2006). Central to this review is the following item within its Terms of Reference:

1. The CEC, as a part of its investigation will review the current environmental protection measures now in place relating to hog production in Manitoba in order to determine their effectiveness for the purpose of managing hog production in an environmentally sustainable manner.

In January 2007, the CEC entered into discussions with the International Institute for Sustainable Development (IISD) to assist in fulfilling its Terms of Reference item #1. In March, IISD produced a concept paper for the CEC. This in turn resulted in the preparation of two research papers (Task 1 and Task 2).

1.2 Task 2 Project Objective

IISD’s Task 2 for the CEC (Industry Development Review Process and Policy) is defined as:

Applicable planning, agricultural, and environmental legislation will be considered within the *Total Nutrient Loading Framework* for the case of a hypothetical hog proponent (Proponent X) to draw implications.

Following this analysis, recommendations will be proposed for Manitoba’s current hog industry development review process. This will identify relevant and redundant planning/review procedures related to the hog industry.

1.3 Research Methods

In completing Task 2, IISD has conducted the following:

1. Advancement of a conceptual analytical framework for total nutrient loading in Manitoba;
2. A review of current Manitoba policy and legislation related to hog industry development;
3. Consideration of existing planning/review mechanisms which could be employed in support of improved decision-making related to hog barn siting; and
4. Preparation of proposed recommendations focused on strengthening Manitoba's hog industry planning/review mechanisms with the goal of reducing total nutrient loading within a watershed-based decision-making framework.

1.4 The Total Nutrient Loading Concept

In Task 1, Using the IWRM cycle and policy instruments discussed in Section 3 of the Task 1 report, an effective *Total Nutrient Loading (TNL) Framework* was developed based on the Integrated Water Resources Management (IWRM) cycle initially outlined by Jølich-Clausen (2004) and refined by Swanson (2005). In addition, a number of potential policy instruments which governments can utilize to improve decision-making and sustainability were also incorporated (IISD and TERI 2003).

The development of a TNL Framework is driven by concerns regarding the health of a watershed, usually about a particular water resource. The design and implementation of such a framework is in itself the application of an *institutional* policy instrument. It would logically take the form of a "Total Nutrient Loading Strategy" centered on the institutionalization of watershed-based planning and management founded on the concepts of IWRM.

An effective TNL Framework would indicate to decision makers and other stakeholders concerned with the health of a water body, exactly what current levels of nutrient loading exist within a particular watershed – and how these would be affected by the incremental increase of one new hog barn. If this could be achieved, the planning process would benefit from the increased knowledge related to the various nutrient sources and removals.

Meanwhile, all stakeholders concerned about the health of a particular watershed would have greater knowledge regarding the incremental impact of one new hog barn on *Total Nutrient Loads*, offering greater clarity regarding this impact and greater comfort for those who are responsible for making the decision. Ideally, this would result in sustainable water resource management through an informed implementation process.

1.4.1 IWRM's Key Monitoring Element

For the purposes of this project, the primary focus is on the fourth stage in the IWRM planning process (Figure 1-1): “Monitoring, Evaluation, and Improvement.” Development of a *Total Nutrient Loading Framework* for Manitoba should logically focus on improving Lake Winnipeg water quality as an ultimate goal, as much of the water flowing in and through the province influences this iconic water body. However, in order to make progress on Lake Winnipeg, its composite watersheds must become a central focus for action. Lake Winnipeg water quality will improve if the nutrient loads associated with its various drainage components (at various scales) can be reduced.

As noted in Task 1, relative nutrient contributions from many sources must be considered, particularly the interrelated elements of *Manitoba Watershed Processes* which include “natural background/undefined” and “present-day agriculture.” The importance of hydrologic connectivity – linking headwater streams to downstream water bodies – must also be incorporated, as does hydrologic scale. Also, the pivotal role of phosphorus and our current understanding of its export in particulate and dissolved form – from agricultural lands and through streambed and streambank erosion influence – must also be considered in some detail.

The ability to monitor water quality trends from individual hydrologic unit to the watershed, basin, or regional level is fundamental to understanding and/or utilizing the full potential of a *Total Nutrient Loading Framework*. In addition, this degree of monitoring would also serve to track the impacts of various IWRM initiatives, including those related to manure management.

Scientifically valid indicators of watershed health would need to be developed and monitored based on rigorous sampling protocols. Based on observed trends, progress toward nutrient loading reduction within each hydrologic unit could be observed, with determinations made as to whether this progress was due to various IWRM initiatives, or some other factors.

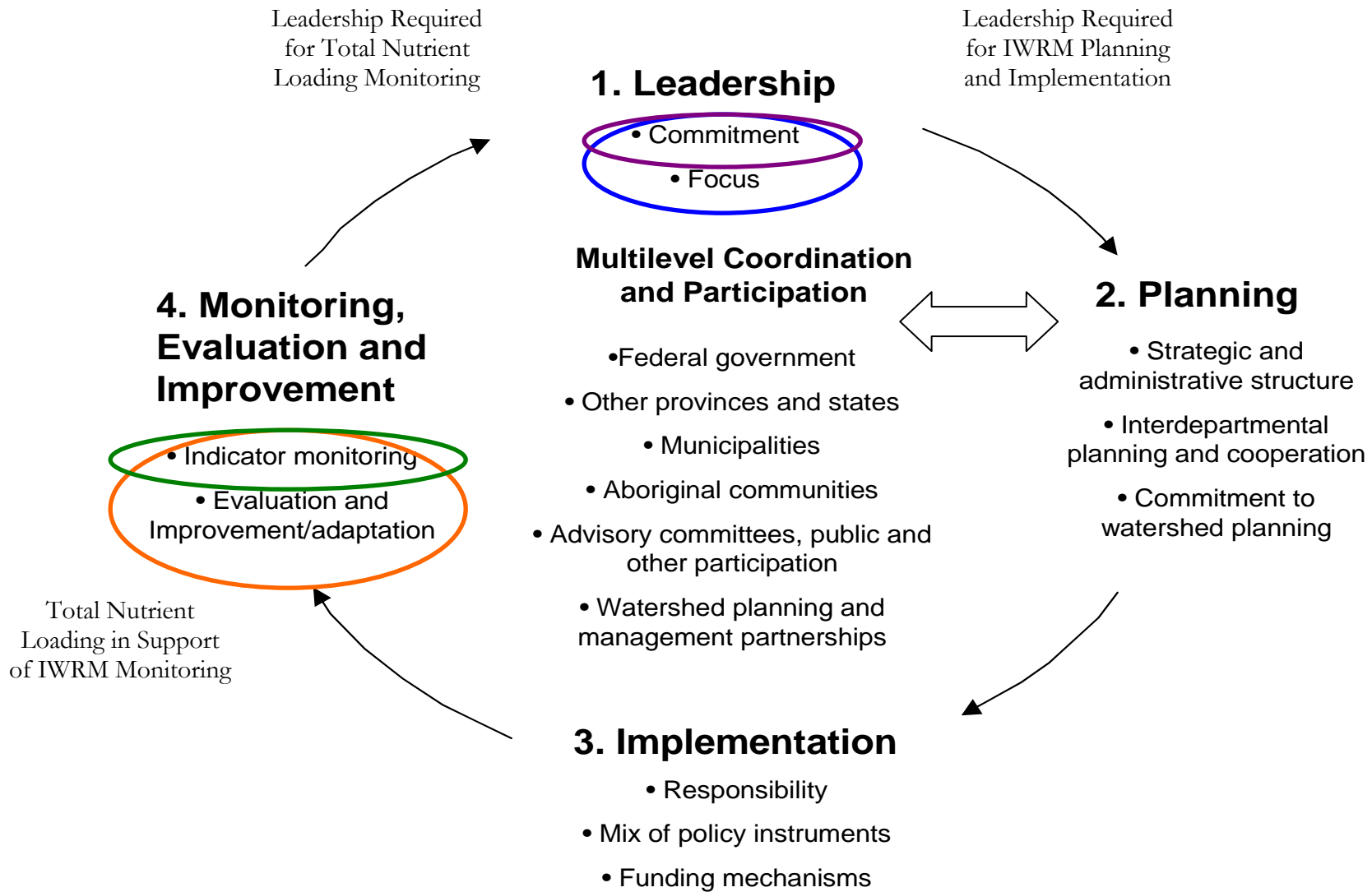


Figure 1-1: Total Nutrient Loading/Monitoring/Planning within the Context of IWRM
 Source: Adapted from Swanson et al (2005)

1.4.2 The Need for Leadership and Coordination

Figure 1-1 also denotes the centrality of “Leadership” in the IWRM planning cycle. Without leadership, there can be no effective IWRM Planning and Implementation or Monitoring, Evaluation, and Improvement. As such, without leadership there can be no *Total Nutrient Loading Framework* and no improvements in Lake Winnipeg water quality.

With regard to these issues, the Province of Manitoba is the most appropriate authority to provide the leadership which is required to address the province’s nutrient loading challenges. Given its authority over most aspects of natural resources management, Manitoba is responsible for most aspects of surface water management, agriculture, land use, environmental quality, and most municipal rural or urban issues related to municipalities.

Given these interrelated responsibilities, which are managed through the operations of numerous provincial government departments, effective provincial leadership would necessarily involve a high degree of interdepartmental planning, communications, and performance measurement. This is required to bring focus to the challenge of nutrient management, to harness the collective influence and full resources of government.

With the health of the province’s signature water body serving as the focus for provincial action, it would logically be accepted that any provincial efforts related to IWRM or development of a *Total Nutrient Loading Framework* would, by their very interrelated and interdepartmental nature, involve the highest possible level of support, from the highest offices of government. This is required to demonstrate the full commitment of government to the nutrient management challenge.

To be truly province-wide in nature, such provincial leadership would not be entrusted to only one department – but to several – under the direction of a designated Executive (Cabinet) Committee or perhaps the Premier, as the President of Executive Council. Such an approach would necessarily involve a high level of strategic coordination.

Leadership does take this form in other provinces where water issues have become major provincial priorities, such as in Alberta and Saskatchewan. In these provinces, provincial strategies related to safe drinking water and the implementation of watershed-based solutions have received the highest levels of Executive Council support, significant funding, and designations as *Cross-Government Strategies* for which several departments are accountable. These *Cross-Government Strategies* are also governed by clear guidelines for interdepartmental planning and reporting.

1.5 Depicting a Proposed TNL Framework

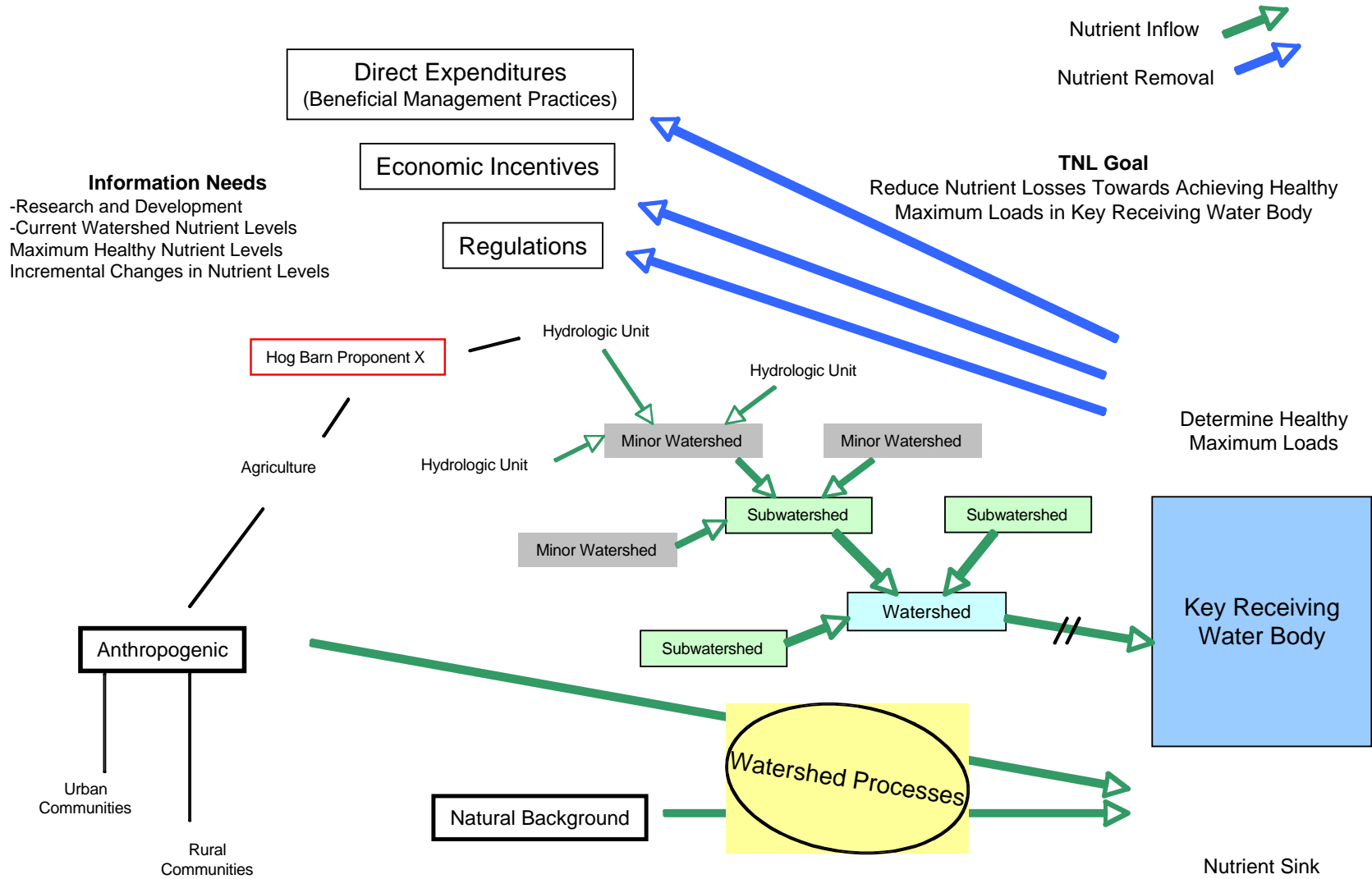
The challenge for Manitoba now, is the delivery of an effective institutional framework for IWRM planning, implementation, and performance measurement. Choosing the right scale at which nutrient loads can be monitored and analyzed for effective nutrient loading reduction may differ across the province, based on such factors as soil types, topography, land use, and development intensity. IWRM is also largely a question of governance – of how individuals and groups can come together – to address mutual concerns related to the health of their watershed community.

Determining exactly when participating individuals, organizations, and communities are ready to collaborate and implement watershed-based solutions is a nascent research topic. The common drainage areas shared by communities should be *meaningful* to the people who live in them and use their resources. They should also be *manageable* so that local governance entities such as local municipalities, watershed districts, and other community stakeholders may in fact have significant influence in improving their condition. For these reasons, it seems most logical that the focus for IWRM (and TNL Loading) should be on the watershed or subwatershed level.

Figure 1-2 outlines the flow of nutrients through drainage system. This *Total Nutrient Loading Framework* demonstrates the cumulative effects of numerous individual hydrologic units, minor watersheds, and subwatersheds – supplying multiple watersheds – which in turn comprise several subbasins, larger basins, and subregions (not depicted) – which ultimately drain into a major water body. This framework also indicates how the use of various policy instruments such as regulation, direct expenditures (e.g. BMPs), and economic incentives could reduce the outflow of nutrients into the watershed and ultimately the sub-region. The focus is decidedly limited to the watershed level (and below), to reflect the reality that 3000 km² (watershed) or 1000 km² (subwatershed) represent an appropriate scale for watershed planning and management to occur. Watershed activities occurred at this scale are most *meaningful* to the residents and communities living within them, and most *manageable* in terms of the degree of cooperation and participation which may be required among individuals and groups – whether working at the individual hydrologic unit, minor watershed, or above.

The ability to assess the *Total Nutrient Loading* impact of one new hog barn development within any hydrologic unit could and should be the objective of an effective TNL Framework. An analysis of this aspect of the TNL Framework – exploring the current and a possible future decision-making process related to such a development (Proponent X), shall be the focus of our work in this report.

Figure 1-2: Total Nutrient Loading Framework (Watershed/Subwatershed Focus)



1.5.1 TNL Framework Components

The ultimate focus of the TNL Framework is on understanding and addressing changes in the health of Manitoba's watersheds, at various scales (from individual hydrologic units to basins, and regional water systems). The health of a water resource is of critical importance to the overall sustainability of a region, as it influences all social, environmental and economic factors.

In reality, the development of a TNL Framework represents one component of a comprehensive IWRM strategy. Other key elements would include the management of excess water flows during periods of intense precipitation, planning for drought, managing other contaminants, and improving overall water use efficiency in agriculture, industrial, and domestic settings. However, with a present need to focus on nutrient reduction, understanding several key aspects is required. These include the following:

1.5.1.1 Research and Development

Research is a fundamental component of a TNL Framework. Several questions still remain about nutrient movement from individual hydrologic units, through a watershed, and finally into a regional level water body. The research component assists in determining the maximum allowable levels of nutrients in the water, as well as monitoring nutrient levels in streams, rivers and lakes. The research activities usually lead to the development and recommendation of beneficial management practices. The results of the research influence watershed management decisions.

1.5.1.2 Current Watershed Nutrient Levels

Knowledge regarding current nutrient levels provides information necessary for the determination of which policy instruments may be most appropriate to improve downstream water quality. The various instruments used will either be: regulatory, expenditure, or economic in nature. In order to ensure that current nutrient levels (and their sources) are well understood, a significant degree of watershed monitoring will be required – from the individual hydrologic unit to the basin or regional level. It is likely that some of this required monitoring could be undertaken through the use of “representative watersheds” which have similar watershed and landscape features to others.

1.5.1.3 Maximum Healthy Nutrient Limits

An approximation of the maximum healthy nutrient limits for a watershed should be known for each contributing drainage system, as well as for downstream water bodies. Unfortunately, the maximum healthy nutrient levels are not known in most cases, so precautionary limits should be used in the interim. While exact numbers may not be known, estimates can be used to promote nutrient reduction activities.

1.5.1.4 Incremental Changes in Nutrient Levels

The final element in the design of a TNL Framework would involve the ability to track incremental changes in nutrient loads within a watershed. These may result from either natural or anthropogenic sources, and they may be either positive or negative – in terms of their influence upon *Total Nutrient Loading* of the particular hydrologic unit being assessed.

Increased nutrient loads may occur in association with increased (or more intense) precipitation, which in turn causes increases in erosion and the movement of both dissolved and particulate nutrients downstream. These loads may also increase due to wastewater discharges from municipal sewage treatment facilities or agricultural runoff – among many other natural background or anthropogenic sources. As noted in Task 1, a substantial portion of these loads are in some way related to watershed processes, and a very significant portion of these arise from within Manitoba.

Nutrient loads within a watershed may also decrease due to natural factors, such as the type and mass of particular forms of riparian vegetation. The effective application of various policy instruments can also serve to reduce watershed nutrient loads. They may decrease in association with: various types of BMPs and effective watershed management coordinated by a conservation, farming, or other organization (expenditure instrument); specific regulations designed to reduce nutrient loading (regulatory instrument), or the use of particular incentives (economic instrument).

However, the primary focus of this project is centred on understanding how the individual decisions of private agricultural landowners (primarily hog producers) actually affect *Total Nutrient Loading*, and how these impacts can be reduced – through the application of various policy instruments. It is these incremental changes (and decisions) which are of the greatest interest at this time. The proposed TNL Framework will demonstrate how the impact of one additional hog barn development may theoretically be assessed in terms of its incremental impact on watershed health.

1.5.2 TNL Policy Instruments

IWRM approaches, actions, and solutions need to be explored from the perspectives of federal and provincial governments, rural municipalities, landowners, production decision-makers, and society. This is essentially the same group of stakeholders, which are ideally also responsible for IWRM planning, implementation, and performance measurement. Key decisions are made by all participants, and their various land use and water-related decisions occurring within a particular watershed can result in downstream impacts of many types.

The development of a *Total Nutrient Loading Framework* is a logical approach to understanding, acting, and measuring progress toward reduced nutrient loads from the contributing watersheds of a downstream water body, these same composite watersheds, or general environmental quality.

Using sound science as a foundation, many social, economic and environmental impacts can be evaluated and adapted to – through a variety of policy instruments available to government, including: **institutional** instruments (internal education, strategies, policies, and procedures); **regulatory** (laws, regulations, and enforcement); **direct expenditure** (broad or targeted programs, education and awareness, and research and development); and **economic** instruments (taxes, fees, and incentives). Any policy instrument is comprised of two elements – design and implementation (IISD and TERI 2003).

1.5.2.1 Institutional Instruments

These include government strategies, new or revised institutional structures, and changes to policy and procedures of governments.

1.5.2.2 Regulatory Instruments

Regulations are one of the tools used by governments of all levels to restrict activities that are concerns for an entire sector, as an example, there are restrictions on how wastewater is managed.

1.5.2.3 Expenditure Instruments

Direct program expenditures designed to achieve particular goals may include the funding of various beneficial management practices (BMPs) to improve the condition of an area of concern. In the case of water quality, certain BMPs can reduce the flow of nutrients into a water body. BMP development and implementation should be based on encouraging individual decision makers to change their practices and remain with that particular practice after funding has expired.

1.5.2.4 Economic Instruments

These may involve incentives and/or changes to the tax system to encourage or reward individual decision-makers for changing the way they undertake certain activities.

1.5.3 TNL Hydrologic Scale Considerations

Nutrient loading throughout any drainage system can occur naturally and anthropogenically within each composite hydrological unit. The summation of these inputs determines *Total Nutrient Loading* levels for each particular watershed (at any scale). From a monitoring perspective, more data is typically better than less, and as such, measurements from each hydrological unit within the watershed hierarchy would be considered ideal. Realistically, however, this is not always possible or necessarily the most efficient method of measurement. Developing a TNL Framework requires an appropriate scale to be effective for a particular watershed system.

Selecting the appropriate scale for measurement requires an understanding of the regions hydrological classifications and the activities within each watershed and its sub-units. Table 1-1 outlines the hydrologic levels introduced in Task 1, their classification name, and the approximate area of each classification. Landscapes, climatic conditions, and anthropogenic activities tend to differ between each watershed and result in different nutrient loading potentials.

Table 1-1: Hydrologic Scales within a TNL Framework

Hydrologic Level	Classification	Approx. Area Limit
1	Region	1,000,000 km ²
2	Subregion	300,000 km ²
3	Basin	150,000 km ²
4	Subbasin	30,000 km ²
5	Watershed	3000 km ²
6	Subwatershed	1000 km ²
7	Minor Watershed	100 km ²
8	Ind. Hydrologic Unit	10 km ²

More detailed monitoring provides more information about nutrient sources, but at a watershed level this detail may not provide sufficient information to develop effective strategies for reducing nutrient loads. Total nutrient monitoring needs to be based on the value of information received and the costs associated with the measurement.

There are still un-answered questions relating to the source of nutrients that need to be further researched. Intensive monitoring and research are gradually increasing the available knowledge surrounding nutrient loading. With this research, the effectiveness of nutrient source and removal models are becoming more accurate, possibly resulting in the need for less physical monitoring within each watershed.

1.5.4 Proponent X Hog Development within the TNL Framework

The focus of this research is on the incremental increases in nutrient loading which one additional (or expanding) agricultural producer of hogs may or may not be contributing, as one component of overall nutrient loads to Manitoba’s downstream drainage systems.

Figure 1-2 situates such a producer as Proponent X within the *Total Nutrient Loading Framework*. This operation can be expected to contribute a measurable portion of total nutrient loads – simply by the fact that it is developed agricultural land, an *Anthropogenic* source of nutrients from rural Manitoba.

The storage of manure as part of this operation represents a certain degree of risk which can be estimated. Meanwhile, the application of manure to its surrounding fields suggests the possibility that some proportion of the nutrients within this manure may not be taken up by growing crops, and find its way into an adjacent drainage ditch and other water bodies downstream. Proponent X is also positioned at the beginning of the nested watershed system as an “individual hydrologic unit,” which along with similar agricultural operations, each contribute surface water flows to the overall system.

Surface water flows from agricultural landscapes are accentuated by: the clearing of natural vegetation as part of the agricultural development process; on-farm agricultural drainage

systems designed to enhance production; the type of crops, land management, and/or production techniques utilized on the farm; and the construction of roads, artificial drains, and culverts designed to facilitate settlement, transportation, and agricultural production in general. In most cases, these influences have been in place for decades, while others are new.

Increased surface water flow can generally be expected to result in corresponding increases in nutrient loads. While they are a direct result of agricultural development of Manitoba's Prairie landscape, these accentuated surface water flows (and nutrient loads) have been typically considered as a *Natural Background* contribution to overall loads reaching Lake Winnipeg (Lake Winnipeg Stewardship Board 2006).

In Task 1 of this research, the watershed-based linkages associated with water flowing from individual hydrologic unit to larger water bodies downstream – and the fact that all watershed processes (which anthropogenic or natural in nature) – should be considered together in attempting to address the challenge of nutrient management through a *Total Nutrient Loading Framework*.

1.5.4.1 Key Information and Policy/Process Gaps

Depicted to represent any Manitoba hog producer (or other livestock operator), when considering a decision to invest in a new development (or expand an existing one), Proponent X currently faces a decision-making process and several pieces of legislation which – it has been suggested – could be significantly improved.

Most current policy and process related to hog industry development centres on the *Technical Review Committee* (TRC) process, which occurs under the auspices of the Manitoba Planning Act. Proponent X is primarily concerned with the expedient production of the TRC report – which can facilitate a decision by the local *Planning Authority* (a planning district or rural municipality) whether to approve the proposed development as a conditional use, or not.

Many Manitoba Rural Municipalities have struggled with decisions related to the development of new hog barn and associated operations, and the fact the TRC process may not be providing the information they require to make effective decisions. Expectations for the TRC process may well be exceeding its intentions as originally designed.

Municipal ratepayers and others living within communities affected by new or expanded hog industry developments – in addition to other Manitobans beyond these communities – have expressed significant concerns related to some developments. It is clear that a improved decision-making process should be explored.

Many of these issues related to the need for better scientific and other information related to the cumulative impacts of incremental increases in the livestock sector, with a particular focus on Total Nutrient Loads within the Lake Winnipeg drainage system. This report seeks to review current policy and decision-making processes related to these issues, with a view toward considering possible improvements which could be made. These are outlined in the form of *Summary Conclusions and Recommendations* in Section 4.

2 Review of Applicable Policy and Watershed-Related Legislation

2.1 COSDI and the Sustainable Development Act

After an aborted attempt to implement a landmark sustainable development act in the mid-1990s (involving the consolidation of many related pieces of legislation), a simplified *Manitoba Sustainable Development Act* was later passed in 1998 – committing to the concept of large area planning, regular sustainability reporting, sustainable development codes of practice, financial management guidelines, and continuation of the Manitoba Round Table.

A subsequent stakeholder consultation resulted in the *Report on the Consultation on Sustainable Development Implementation (COSDI)* in 2000. The COSDI report called for Manitoba to make better environmental, land use, and resource allocation decisions – employing the concept of “large area planning,” based on naturally definable areas, such as watersheds. This set the stage for a major discussion paper, based on the first six water policy themes outlined below and within *Building a Sustainable Future – Water: A Proposed Strategic Plan for Manitoba*, released in October 2001 (Manitoba Conservation 2001).

2.2 The Manitoba Water Strategy

Manitoba’s Vision for its freshwater resources is stated within the Manitoba Water Strategy (Manitoba Water Stewardship 2007), which foresees:

“The best water for all life and lasting prosperity.”

The strategy’s Key Goals (described as Policy Areas and Objectives) are focused on:

1. Water Quality – To protect and enhance our aquatic ecosystems by ensuring that surface water and ground water quality is adequate for designated uses and ecosystem needs.
2. Conservation – To conserve and manage the lakes, rivers, and wetlands of Manitoba so as to protect the ability of the environment to sustain life and provide environmental, economic, and esthetic benefits to existing and future generations.
3. Use and Allocation – to ensure the long term sustainability of the province’s surface water and ground water for the benefit of all Manitobans.
4. Water Supply – To develop and manage the province’s water resources to ensure that water is available to meet priority needs and to support sustainable economic development and environmental quality.
5. Flooding – To alleviate human suffering and minimize the economic costs of damages caused by flooding.
6. Drainage – To enhance the economic viability of Manitoba’s agricultural community through the provision of a comprehensively planned drainage infrastructure.

A stakeholder steering committee undertook a review of the strategic plan, providing ministerial recommendations which led to the current Manitoba Water Strategy, released in April 2003. Past activities and proposed future actions are outlined for each of the six policy themes/detailed objectives, while the implementation framework for the strategy is outlined (Manitoba Conservation 2003 20-23). The implementation elements include:

I. Development of an Integrated Water Planning and Management System

Watershed-based planning will be supported through the creation of “watershed districts” (subsequently called “watershed planning authorities”) across the province, building on the existing efforts of Manitoba’s conservation districts – which are primarily based on municipal boundaries, but employ sub-watershed-based local committees. Larger basin-level or aquifer districts may also occur where appropriate. Planning partners will be important at every level.

II. Review and Consolidation of Water Legislation

There are at least 20 separate provincial acts and several more legislative regulations related to water in Manitoba. The province hopes to consolidate most existing water legislation into a single act, based on extensive public consultation. Some acts will be repealed, some may be revised, and some (such as those related to federal legislation) may not change or be consolidated. Relevant water legislation includes:

- Conservation Agreements Act	- Conservation Districts Act
- Drinking Water Safety Act	- Dyking Authority Act
- Fisheries Act	- Fishermen’s Assistance Act
- Floodway Authority Act (crown corporation)	- Groundwater and Water Well Act
- Manitoba Habitat Heritage Act (crown corp.)	- Lake of the Woods Control Board Act
- Manitoba Natural Resources Transfer Agreement	- Public Health Act (relating to drinking water)
- Water Commission Act (repealed)	- Water Power Act
- Water Resources Administration Act	- Water Supply Commissions Act
- Water Services Board Act (crown corporation)	- Water Rights Act
- Water Protection Act	- Water Resource Conservation and Protection Act

III. Development of Mechanisms for Financing Water Management and Planning

Locating adequate, long-term funding in support of comprehensive water management has been an ongoing challenge, although crisis-related funding is more readily available (i.e. flooding). Funding to support the maintenance of provincial waterways, and watershed restoration projects will be expected to reflect an equitable distribution of costs, in accordance with benefits received among all users.

2.2.1 The Water Protection Act

Manitoba Water Stewardship is a relatively new provincial department responsible for implementation of the Manitoba Water Strategy. Manitoba has begun to formalize its water policy direction by drafting the *Water Protection Act*. The Act supports additional legislative efforts passed under the Drinking Water Safety Act, which saw the creation of the Office of Drinking Water – with associated enforcement, inspection, and advisory powers regarding the operation of any public or private water supply system. The Act (Manitoba Statutes 2007), was designed to:

- Enshrine water quality objectives and standards in legislation;
- Commit to ongoing consultation through the Manitoba Water Council;
- Formalize a provincial commitment to watershed-based planning (through the recognition of “watershed planning authorities,” ideally comprised of existing conservation districts;
- Establish “water quality management zones” requiring specific action based on the sensitivity of draining water bodies to nutrient loading (based on soil type and land use); and
- Establish a Water Stewardship Fund.

The Water Protection Act is expected to significantly advance the concept of land and water management planning – on a natural systems basis (watersheds). The legislation is attempting to address many of the systemic, institutional, cultural, and traditional barriers to effective watershed management.

The Act contains two very significant parts which outline a number of relevant items which are germane to the hog industry in Manitoba. The focus in Part 2 is on “water protection,” including provisions for the adoption of water quality standards, objectives, or guidelines in s. 4(1). This will occur in conjunction with the existing provisions of the *Environment Act*, as noted in s. 4(2).

2.2.1.1 Water Quality Management Zones

Sections 5 and 6 of the *Water Protection Act* allow for the designation of “water quality management zones,” regulations and prohibitions associated with any type of land use occurring within these zones, the consideration of scientific information, existing water quality standards, and scientific requirements for the provision of ministerial advice by departmental staff in response to an objection. Several key sections are noted below:

5(1) *On the recommendation of the minister, the Lieutenant Governor in Council may make regulations*

- (a) designating any area of the province as a water quality management zone for the purpose of protecting water, aquatic ecosystems or drinking water sources;*
- (b) governing, regulating or prohibiting any use, activity or thing in a water quality management zone or any part of a zone.*

5(2) Before recommending that a regulation be made under subsection (1), the minister may consider scientific and other information relating to

- (a) the physical characteristics of land in the area, including its topography and soil types;
- (b) the ability of the soil or water in the area, or water downstream of the area, to assimilate nutrients and other pollutants;
- (c) water bodies or groundwater in the area, including information relating to
 - (i) the water quality characteristics of the water,
 - (ii) the susceptibility of the water to contamination or adverse changes in level or in-stream flow, and
 - (iii) the extent to which the water is pristine or relatively undisturbed by human activity;
- (d) the area's aquatic ecosystems;
- (e) whether the area contains a source, or a potential source, of drinking water;
- (f) whether the area supports species that are sensitive to alterations in water quality or quantity resulting from human activity;
- (g) whether the area provides habitat for endangered species; and
- (h) any other matter that the minister considers relevant.

Section 5(1) clearly outlines Manitoba Water Stewardship's strong powers and responsibilities regarding the control of any land use activities which may be undertaken within a designated water quality management zone. These powers have been criticized by the agriculture industry in particular (for setting the stage to penalize farmers) and from some environmental organizations (for being too weak).

Meanwhile Section 5(2) outlines the comprehensive nature of the zone designation process. The considerations required before any water quality management zones are announced are comprehensive and scientific in nature, clearly denoting the importance of maintaining a rigorous database of watershed information by the province. However, this information is not readily available or in a useable form for watershed-by-watershed analysis. Appropriately, the regulation which would bring the use of these zones into place has yet to be registered by Manitoba Water Stewardship.

Section 5(3) refers to the need for Manitoba Water Stewardship to consider any existing and applicable water quality standards and approved watershed management plans before designating a water quality management zone. There is an extensive history associated with the development of provincial water quality standards through Manitoba Conservation and earlier versions of this department (Manitoba Conservation 2002), although no regulation formally implementing these standards has been registered by Manitoba Conservation. To date, only one watershed plan has been completed, and formally adopted by Manitoba Water Stewardship (TMCD 2004). Both of these elements demand a strong scientific foundation.

In section 6, the need to consult with a “water planning authority” is also noted. While there are other options are prescribed within the *Water Protection Act* regarding the composition of these authorities, to date only conservation districts have been designated as such, most of which are not watershed-based organizations.

The foundational importance of science is again highlighted in s. 7(5), 7(6), and 8 where a rigorous requirement exists for expert scientific and technical advice – in responding to objections and/or in reviewing the effectiveness of any water quality management zone regulation. Given the demonstrated connection between phosphorus loading and hydrologic flow, it would be most logical for Manitoba’s water quality management zones to be based along watershed boundaries. There is a need for greater technical capacity and stronger watershed science throughout the province is clear, as noted below.

7(5) Within 60 days after notifying the minister of the objection, the director must give advice to the minister as to whether the proposed regulation should be varied or revised.

7(6) Before providing advice under subsection (5), if the director determines that there is an unresolved scientific or technical issue, he or she must obtain expert advice in such a manner as may be set out in the regulations.

8 The minister must, not later than five years after the date on which a regulation under section 5 comes into force, require the water council to

- (a) review the effectiveness of the regulation and, in the course of that review, consult with any persons affected by the regulation that the council considers appropriate; and*
- (b) recommend, if it considers it advisable, that the regulation be amended or repealed.*

The minister may, in addition, require the council to undertake such a review at any other time.

2.2.1.2 Watersheds and Water Planning Authorities

Equally significant is Part 3 of the Act, referring to designation of “watersheds” and “water planning authorities.” Section 14 notes that:

14 The Lieutenant Governor in Council may by regulation

- (a) designate a watershed for the purposes of this Act, and specify its boundaries;*
- (b) designate a water planning authority for a watershed, which may be
 - (i) the board of a conservation district,*
 - (ii) the board of a planning district,*
 - (iii) the council of a municipality,*
 - (iv) any other person or entity, or*
 - (v) a joint authority consisting of two or more entities or persons described in subclauses (i) to (iv);**
- (c) prescribe the date by which the authority must submit a watershed management plan for approval, terms of reference for the preparation of the plan, and any other terms or conditions that the Lieutenant Governor in Council considers necessary.*

2.2.1.3 Watershed Management Plans

Sections 15 and 16 outline the requirements for the preparation of a watershed management plan, as well as its mandatory contents:

15 In preparing a watershed management plan, a water planning authority must consider the following:

- (a) water quality standards, objectives and guidelines that apply to the watershed;*
- (b) whether a water quality management zone is included within any part of the watershed, and if so, any regulations made under section 5 respecting the zone;*
- (c) studies that the authority considers relevant relating to water, land use, demographics, the capacity of the environment to accommodate development, and any other matter related to present or future physical, social or economic factors;*
- (d) comments received through public consultation or public meetings held under section 17;*
- (e) prescribed water management principles;*
- (f) relevant provincial land use policies, development plans, and zoning by-laws;*
- (g) any other information that the authority considers relevant.*

These sections provide strong clues as to the level of detail, public consultation, and communications which are required for a watershed management plan to be acceptable to Manitoba Water Stewardship. In addition, s. 15.f and 16(1).c denote the obvious and logical linkages between watershed planning and land use planning. Section 16(1).c is particularly important, as it refers to a challenging requirement that the development plan of a planning district or municipality must include “some or all of the provisions of the watershed management plan.”

16(1) A watershed management plan must

- (a) identify issues relating to the protection, conservation or restoration of water, aquatic ecosystems and drinking water sources in the watershed;*
- (b) contain objectives, policies and recommendations respecting some or all of the following:*
 - (i) the protection, conservation or restoration of water, aquatic ecosystems and drinking water sources,*
 - (ii) the prevention, control and abatement of water pollution, including wastewater and other point-source discharges, and non-point sources of pollution,*
 - (iii) land drainage and flood control, including the maintenance of land drainage and flood control infrastructure,*
 - (iv) activities in water quality management zones, riparian areas, wetlands, flood areas, flood plains and reservoir areas,*
 - (v) water demand management, water use practices and priorities, the conservation of water supplies, and the reduction of water use and consumption during droughts and other periods of water shortage,*
 - (vi) the supply, distribution, storage and retention of water, including measures to ensure persons in the watershed have access to clean potable water,*
 - (vii) emergency preparedness to address spills, accidents and other emergencies that may affect water, an*

aquatic ecosystem or a drinking water source;

(c) specify linkages between water management and land use planning so as to facilitate the adoption, in a development plan or other planning instrument, of some or all of the provisions of the watershed management plan; and

(d) identify ways in which the plan can be implemented, monitored and evaluated, recognizing the need to implement the plan with the assistance of individuals, groups, and organizations.

16(2) A watershed management plan may also

(a) contain maps to assist in its interpretation; and

(b) specify a date by which the plan must be reviewed.

The Act is lacking a strong economic incentive component, and The Act's enshrinement of plans to create a Water Stewardship Fund (s. 29) are particularly significant however, creating a direct opportunity for funding watershed management implementation and stewardship solutions, in partnership with other funding sources.

An emerging question relates to the Act's prescription for addressing the long-term challenge of integrated watershed resource management – through the creation of “local water planning authorities.” While the legislation is flexible in how these entities may be created and funded, the department's direction is focused heavily on the existing conservation districts program to facilitate watershed planning and authority creation. Limited watershed planning capabilities at the conservation district level and the means by which to harmonize provincial policy goals with local community interests and priorities represent significant current and future challenges.

2.2.2 Priorities and Timeframes

Water-related issues are currently being addressed on several levels – with a strong focus on Lake Winnipeg water quality. Even prior to development of the Manitoba Water Strategy, the province's main priorities relating to water have focused on (Manitoba Water Stewardship 2007):

- Drinking water safety (act passed in August 2002, Office of Drinking Water created);
- Preventing bulk water export and inter-basin transfers both within and beyond the Hudson Bay Basin (Water Resources Conservation and Protection Act, passed in August 2000);
- Extensive legal challenges to the Devils Lake and Garrison Diversion projects in North Dakota, over concerns regarding downstream water quality and biota transfer;
- Rural community flood protection with ring dykes since the 1997 Red River Flood;
- The provision of timely and accurate flood-related water information and forecasting;
- Winnipeg Floodway expansion (creation of Floodway Authority in June 2004);
- Nutrient management, riparian incentives, and research in support of Lake Winnipeg water quality, and creation of the Lake Winnipeg Stewardship Board (October 2004).

The origins and scope of the Manitoba Water Strategy and the Water Protection Act are rooted on the concept of inter-generational equity, and their intent clearly respects the environmental, economic, and social elements of sustainable development. However, at this time, there are no stated timeframes for any initiatives associated with Manitoba's water policies, strategy directions, or legislative activity.

2.2.3 Watershed Partnerships

Historical and emerging watershed-based efforts exist at several levels. These include:

2.2.3.1 Basin-level Commissions and Advisory Boards

The Red River Basin Commission is a transboundary partnership with multi-stakeholder representation from Manitoba, North Dakota, Minnesota. The organization's main focus is on development of a comprehensive natural resources framework plan for the basin. Manitoba, Minnesota, and North Dakota all support the RRBC, along with numerous municipalities (RRBC 2005). Manitoba also supports the Partners for the Saskatchewan River Basin organization.

In recent years, Manitoba has also supported river basin management advisory boards focusing on the Assiniboine River and Lake Manitoba. The role of the Lake Winnipeg Stewardship Board is to assist the government of Manitoba in achieving the main commitments associated with its Lake Winnipeg Action Plan of reducing phosphorus and nitrogen in the lake to pre-1970 levels (Lake Winnipeg Stewardship Board 2007). Board members represent a variety of interests, including fishing, agriculture, urban land use, First Nations, federal, provincial and municipal government, and non-governmental organizations.

2.2.3.2 Local Watershed Organizations

Several Manitoba rural municipalities in the Red River Basin and Interlake area have been working together in an attempt to address longstanding drainage issues outside of the conservation district framework. Similar cooperative efforts have occurred in the past, typically following major flooding events. Today's North West Red Water Management Association is comprised of several south-central Manitoba municipalities – virtually the same membership as an earlier entity, the Lower Red River Valley Water Commission, a municipal partnership body which became active after the Red River flood of 1950.

There also a number of active watershed restoration associations operating within the City of Winnipeg, notably on the Seine River, Bunn's Creek, and through the Assiniboine Watershed Network (involving the Sturgeon, Truro, and Omand's Creek systems).

There is a long history of federal/provincial partnerships related to soil conservation and sustainable agriculture, dating to 1989, during which the Canada-Manitoba Soil Conservation Agreement was used to establish 44 local agricultural conservation organizations known as "Farming for Tomorrow" groups. Most organizations remaining today work in partnership with, or have formed a conservation district. Many others have disbanded.

One very active organization remaining today is the Deerwood Soil and Water Management Association, which operates a long-term, scientific watershed research project in south-central Manitoba at South Tobacco Creek (Deerwood 2003). Deerwood works in partnership with the federal and provincial governments, universities, local municipalities, and others. The organization is currently focused on evaluating beneficial management practices (BMPs) under Agriculture and Agri-Food Canada’s *Watershed Evaluation of BMPs* (WEBs) program and expanding their scientific research, management planning, and performance measurement to the next watershed level, in partnership with two conservation districts and five municipalities, known as the *Tobacco Creek Model Watershed* (Figure 1) (TCMW 2004).

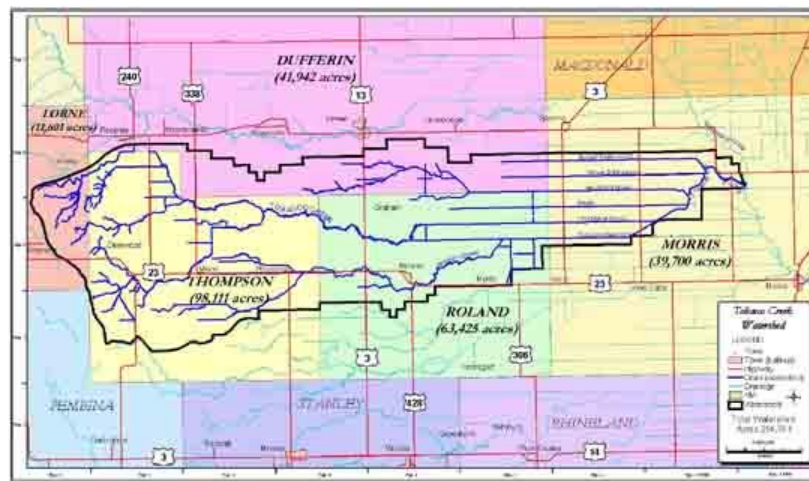


Figure 2-1: Rural Municipalities and the Tobacco Creek Model Watershed
Source: TCMW 2004

2.2.3.3 Conservation Districts

Under the Manitoba Water Strategy and the Water Protection Act, integrated watershed resource management planning is expected to occur primarily via the Manitoba Conservation Districts Program – an existing Agri-Manitoba focused network of provincial-municipal partnerships for improved soil, water, and wildlife management.

Manitoba’s conservation districts are independent local boards sponsored jointly by Manitoba Water Stewardship and partner rural municipalities. Provincial funding is allocated for approved soil, water, and wildlife habitat conservation programming with private landowners – based generally on a 3 (provincial):1(municipal) funding formula.

Since 1970, 18 conservation districts have been established in Manitoba, and these bodies have a long history of providing a wide range of integrated resource management programming, which are generally perceived to be providing a valuable service to all Manitobans. One of their greatest values is a strong connection to rural communities and agricultural landowners in particular – considered vital to their future success – and in assisting to meet provincial water policy objectives outlined in the Manitoba Water Strategy (FT-Ecologistics 1998).

While the earliest conservation districts were established along watershed boundaries, the majority of those existing today are based upon municipal boundaries. A 1998 conservation districts mandate study commissioned by the province noted the need for stronger efforts in support of watershed management and performance measurement (FT-Ecologistics 1998).

Today, their efforts are being increasingly targeted on a watershed basis. Municipal and other conservation district partners are also being encouraged to consider about science-based watershed indicators – to evaluate if programming toward real improvements in watershed health are effective. These future indicators would also support the provincial priority of completing source water protection plans, as outlined in the Water Protection Act.

It is recognized that building local watershed planning capacity throughout the conservation districts network will take time. There are also resource and staffing challenges at the provincial level in providing professional technical and facilitation support. A coordinated data collection and analysis system to establish baseline planning conditions and monitor watershed management progress has also been identified as a critical requirement. Watershed planning initiatives are now underway in several conservation districts, notably in the Pembina Valley, Turtle Mountain, and West Souris River Conservation Districts.

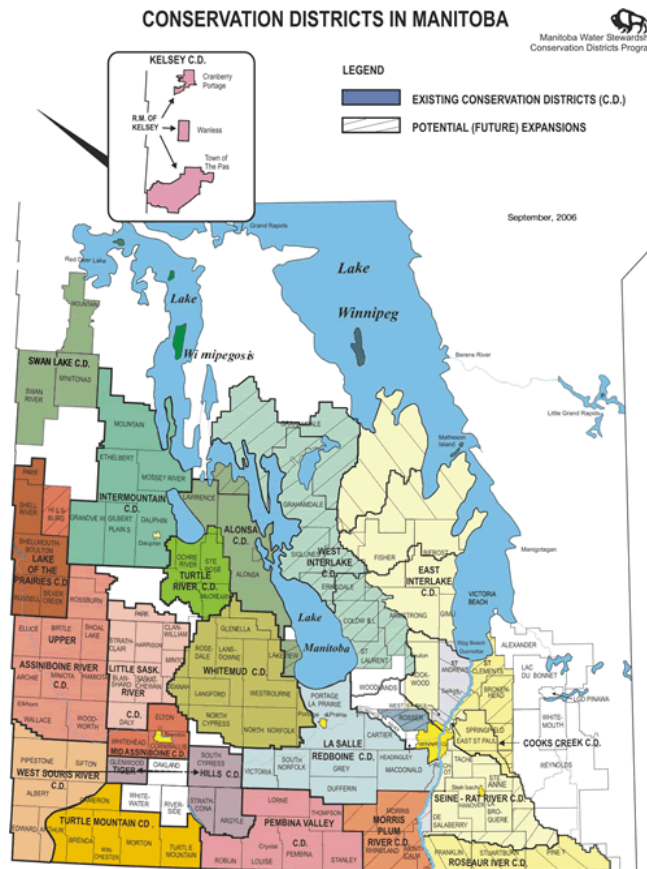


Figure 2-2: Manitoba Conservation Districts, 2007
Source: Manitoba Water Stewardship 2007

2.3 The Environment Act

This section outlines the evolution and current application of the *Environment Act* as it relates to the livestock industry.

2.3.1 Evolution of Early Legislation

in 1871, provincial legislation known as the Sanitary Act was passed with regard to controlling manure deposition along Manitoba's rivers and streams. After several name changes and revisions, this legislation eventually became known as the Pollution of Streams Act in 1891, establishing a 50' buffer zone from the high water mark of any stream, within which any "filthy and impure matter," namely manure, was not be deposited (Vaisey 1979 20).

In 1905, a new legislative focus brought attention to more visible forms of pollution, such as sawmill waste, forbidding obstructions from being placed with in stream channels, and setting out limitations related to stream navigation. This legislation was consolidated with the 1891 act renamed the Rivers and Streams Act in 1913 (Vaisey 1979 20).

In 1935, the Pollution of Waters Prevention Act was passed by the province. It separated, expanded, and highlighted the various water pollution aspects formerly under the original Rivers and Streams Act. Meanwhile, new elements of the Rivers and Streams legislation were added, including conditions under which stream channel alternations could occur, new navigation rules, and provisions to guard against excess sedimentation and bank erosion. Under the Pollution of Waters Prevention Act, the extent of a streambank was increased and redefined as any area within 132' of the normal high water mark. Interestingly, the definition of "filthy and impure" polluting materials was also significantly expanded to include chemicals, poisons, garbage, decomposing materials, and drugs (Vaisey 1979 21).

In addition, one recommendation of the Land Drainage Arrangement (Finlayson) Commission in 1936 focused on the permanent protection of a 75' riparian buffer strips along drains subject to the Land Drainage Act – in order to minimize soil erosion and the introduction of agricultural contaminants into provincial water bodies. Finlayson felt this would also result in impressive water quality results, directly supporting the Pollution of Waters Prevention Act passed the previous year (Vaisey 1979 22).

2.3.1.1 Birth of the Clean Environment Commission

A key element of the 1935 Pollution of Waters Prevention Act involved establishment of a Provincial Sanitary Control Commission, appointed by the Lieutenant Governor. This three person (minimum) commission had an impressive degree of power and authority associated with the protection of Manitoba's water quality. The Commission had general supervisory and investigative powers to explore and address water pollution problems, including the ability to order the halting of deleterious discharges and/or issue licences to permit controlled pollution discharges (Vaisey 1979 23). This act remained in place until 1968, and clearly set the tone for future legislation.

The Pollution of Waters Prevention Act also contained provisions for local municipalities wishing to organize themselves into “sewage districts,” a legislative element which remained in place until 1972. These municipalities could work alone or as a group to form and operate a district, with the purpose of improving sewage management, water quality, and community health. Each district could also make local regulations to prohibit, regulate, or control sewage discharges within the district, subject to approval by the Commission. Also in 1935, due to several years of Prairie drought (loss of the Red River’s assimilative capacity), combined with Winnipeg’s population, new legislation (the Greater Winnipeg Sanitary District Act) saw responsibility for sewage treatment in Manitoba’s capital city become the responsibility of the City itself (Vaisey 1979 24).

Even though the establishment of municipal sewage districts would make their facilities eligible for federal unemployment relief funding (Booy 1975 132-1322, in Vaisey 1979 24), uptake of the sewage district program beyond Winnipeg was not strong, possibly because municipal membership in a district was not mandatory. Ultimately, the province had to assume responsibility for local municipal sewage management beyond Winnipeg, through the Manitoba Water Services Act of 1972, through which the province directly funded and supported Manitoba’s remaining municipalities in managing sewage loads (Vaisey 1979 25).

2.3.2 The Clean Environment Act

In 1968, a new act came into force with a broader focus, beyond water. It involved protection measures aimed at preventing air, water, and soil pollution. The concept of encouraging municipal ‘sewage districts’ was removed, and the concept of licensing polluters was given greater attention. The act was no longer focused mainly on water, as there was a recognition in legislation of the complex, inter-related environmental pathways of pollution, and the need to protect the environment as a whole. The Clean Environment Act was introduced shortly after the 1963 Pesticides Control Act, which mandated the licencing of all distributors of pesticides (Vaisey 1979 25-26).

The 1968 act also saw the re-naming of the Provincial Sanitary Control Commission as the Clean Environment Commission (CEC), affording it “general supervisory powers and control over all matters related to the preservation of the natural environment, and the prevention and control of any environmental contaminants.” The commission could investigate any environmental concern with public hearings and witnesses, and issue licences permitting specific discharges into particular water bodies. This could include the mandating of specific treatment requirements, or the restriction of a development altogether. However, the overriding powers of the CEC came to an end, as the act was again updated in 1972. The CEC’s general responsibility for environmental quality was passed to the Minister, under whom most of its original authority was now placed. The CEC could set discharge limits and issue/revise mitigation Orders only where existing legislation did not address a pollution matter. The Clean Environment Act of 1972 also granted additional authority to the Lieutenant Governor, who, in addition to having the power to make regulations in support of the legislation, could now also, “for environmental reasons restrict or limit the number of industries, undertakings, plants or processes that might be permitted in the province, or any part thereof for such periods of time as might be deemed advisable.” (Vaisey 1979 27-28).

In 1968, the City of Winnipeg was made exempt from the Clean Environment Act's authority, as it was with the 1935 Pollution of Waters Prevention Act. Control of deleterious substances within the city was left to Winnipeg's own authority. In concert with the amalgamation of Winnipeg's 12 founding municipalities in 1972, the new city corporation also maintained authority over the urban environment (Vaisey 1979 29).

2.3.3 Water Quality Objectives and the Manitoba Environment Act

In 1977, the Clean Environment Commission held public hearings to explore and review the implications associated with a proposed system of provincial water quality objectives. The resulting CEC "Report on a Proposal Concerning Water Quality Objectives and Stream Classification for the Province of Manitoba" was accepted by the Minister of Mines, Natural Resources and Environment in Jan 1979. The CEC was then asked to begin the water body classification process, according to current and potential uses. The ultimate result would see the department's Environmental Management Division become responsible for developing and implementing the various guidelines and regulations associated with the Clean Environment Act, and the classification and protection of various water uses with associated objectives (Vaisey 1979 iii, 1-2, 13, 30):

During the early 1980s, the CEC completed use classification and water quality objective assignments for the Souris, Red, and Grass-Burntwood watersheds. Several technical revisions to the program occurred during 1983-84, towards their finalization in 1988. Also during this year, a Manitoba Environment Act was proclaimed, providing legislative support for Manitoba Environment to implement the program of standards, objectives, and guidelines for water quality in the province (Manitoba Conservation 2002 72).

The 1988 Manitoba Environment Act replaced the 1968 Clean Environment Act, as well as a 1975 Environmental Assessment and Review Process. The Act was developed in response to growing public concern for the environment, combined with the desire to support economic development with clear environmental regulations. The Act maintained the role of the Clean Environment Commission as a ministerial advisory body with powers to explore potential environmental concerns, review regulations, and conduct public hearings in the review of proposed developments (Manitoba Environment and Workplace Safety and Health 1988 3, 19).

New concepts introduced in the Act related to a classification process for different levels (types) of development (ostensibly to streamline the development process); a clear environmental assessment and public review process for each of three development levels; specific roles for the administering department (including preparation of an annual "State of the Environment" report); and detailed enforcement procedures for non-compliance with the conditions of issued licences or orders (Manitoba Environment and Workplace Safety and Health 1988 9-18, 24-28).

The Act maintains and strengthens the administering department's authority to develop and implement standard and objectives for environmental quality, including water (s. 2.2c) while these may also be implemented by regulation (s. 41.1e). Manitoba's Water Quality Standards, Objectives, and Guidelines have been regularly reviewed and revised since their initial

proposal in 1976. The current protocol proposes a three tiered approach to improve flexibility in implementation as follows:

Tier 1: Water Quality Standards – to govern the management of common pollutants for which existing pollution abatement technology is available and commonly used (Manitoba Conservation 2002 2-4);

Tier 2: Water Quality Objectives – for Manitoba pollutants controlled through Manitoba Environment Act licencing in accordance with ambient water quality levels based on detailed United States Environmental Protection Agency (US EPA) calculations (Manitoba Conservation 2002 5-35); and

Tier 3: Water Quality Guidelines – a series of numerical and narrative targets to guide water quality decisions affecting a broad range of pollutants, using generalized data provided by the Canadian Council of Ministers of Environment (CCME) (Manitoba Conservation 2002 36-56).

Currently defined water uses include the following (Manitoba Conservation 2002 68-69):

- Drinking Water;
- Cool Water Aquatic Life/Wildlife;
- Cold Water Aquatic Life/Wildlife;
- Industrial and Cooling Water Supplies;
- Greenhouse Irrigation;
- Field, Park, and Garden Irrigation;
- Livestock Watering; and
- Primary Recreation.

The Act (Manitoba Government Queen's Printer 1987-88) also encompasses a number of associated regulations addressing various environmental issues. Most water quality protection provisions are contained within the Water and Wastewater Facilities Operator Regulation (MR 77/2003, 162/2005), the Onsite Wastewater Management Systems Regulation (MR 83/2003), and the Livestock Manure and Mortalities Management Regulation (MR 42/1998, 52/2004, 194/2005, 219/2006).

2.3.4 The Livestock Manure and Mortalities Regulation

MR 42/1998 (along with its recent amendments) prescribes a broad range of requirements for managing agricultural manure, including disallowing manure discharges into surface watercourses or groundwater (s. 11), requirements for approved manure management plans for operations exceeding 300 animal units (s.13), and minimum setback requirements of 3m-35m, depending on application methods and existing vegetated riparian buffer zones as noted in Schedule C (Manitoba Statutes 1998).

2.3.4.1 Manure Storage Facilities

The regulation notes that manure storage can only occur in an approved manure storage facility (s. 4-6) or as field storage (s. 7-8). Section 4 notes that:

4 An operator who stores livestock manure in a manure storage facility shall

(a) ensure that the manure storage facility, alone or in combination with other manure storage facilities located on the property of the agricultural operation, is of sufficient capacity to store all of the livestock manure produced or used in the agricultural operation until such time as the livestock manure can either be applied as fertilizer or otherwise removed from the manure storage facility;

(b) design and construct the manure storage facility, or ensure that it is designed and constructed, so as to prevent the escape of any livestock manure that may cause pollution of surface water, groundwater or soil;

(c) maintain and operate the manure storage facility in a manner that does not cause pollution of surface water, groundwater or soil; and

(d) operate and maintain the manure storage facility in a manner that sustains its structural integrity.

Two key concepts are introduced in section 4 – the need to ensure that adequate manure storage is provided based on the size of the agricultural operation in question, and the fact that an operator is responsible for the design, construction, and operation of the storage facility (and the operator’s land-based and water-related operations around it) so that pollution of surface or groundwater does not occur. These are recurring themes within the regulation, as noted in section 5(5) which states:

5(5) Unless otherwise approved by the director, no person shall create a well or a drainage ditch within 100 m of a manure storage facility, measured in the same manner as the minimum 100 m setback zone provided for in clauses 1(a) and (b) of Schedule A.5(5)

2.3.4.2 Field Storage of Manure

This section makes a clear linkage between land use, hydrologic flow, and the risk of nutrient transport arising from manure storage. These linkages are continued in section 7, with references to the field storage of manure including:

7(1) No person shall store livestock manure as field storage other than solid manure.

7(2) A person who stores solid manure as field storage shall

(a) locate the livestock manure at least 100 m from any surface watercourse, sinkhole, spring or well; and

(b) store the livestock manure in a manner that does not cause pollution of surface water, groundwater or soil.

7(3) An operator shall construct dikes or other works around a field storage area that are effective to prevent the escape of livestock manure that may cause pollution of surface water, groundwater or soil, if generally accepted agricultural practices indicate their necessity. The operator shall maintain the effectiveness of the dikes or other works for so long as the field storage area is used to store livestock manure.

As noted in s. 7(6) and 7(7), after removing all manure from a field storage area by November 10 of the year following initial storage, an operator must not store any further manure in this area for at least one additional year, after a crop has been grown to deplete the area of excess nutrients.

Section 8 contains similar prohibitions as section 7 with regard to manure composting, although via s. 8(2), it is noted that smaller agricultural operations (under 300 animal units) are exempt from the water quality protection regulations included in clause 8(1).a below:

8(1) No person shall compost livestock manure on the property of an agricultural operation unless

(a) the composting site is located at least 100 m from

(i) any surface watercourse, sinkhole, spring or well, and

(ii) the operation's boundaries;

(b) the manure is composted in a manner that does not cause pollution of surface water, groundwater or soil; and

(c) the composting facilities and process are acceptable to the director.

This marks the beginning of a number of exemptions for agricultural operators below the 300 animal unit threshold, which exist – ostensibly to reduce the economic impact of meeting the *Livestock Manure and Mortalities Management Regulation*, or perhaps a recognition of the fact that the environmental impacts of these operators are likely marginal and as such can be overlooked. This logic is confusing, given that a high number of smaller operators could well result in a significant environmental impact.

2.3.4.3 Water Quality Protection

Sections 11 and 12 contain some logical and basic regulations designed to encourage the protection of downstream water quality:

11(1) No person shall handle, use or dispose of livestock manure, or store livestock manure in an agricultural operation, in such a manner that it is discharged or otherwise released into surface water, a surface watercourse or groundwater.

11(2) An operator shall ensure that livestock manure that is handled, used, disposed of or stored in an agricultural operation is not discharged or otherwise released into surface water, a surface watercourse or groundwater.

12(1) No person shall apply livestock manure to land other than as fertilizer on land on which a crop

(a) is growing; or

(b) will be planted during the next growing season.

Section 12(1.3) is also very logical, recognizing the reality that class 6 and 7 agricultural lands are generally the steepest and most erodible lands which exist. These soils are typically quite marginal, as are most “unimproved organic soils” which are not already in production. However any agricultural operation which existed prior to the registering of this regulation is exempt from this provision via s. 12(1.7), unless Manitoba Conservation believes there are water quality risks associated with these operations. There are many instances where class 6 and 7 land is cropped in Manitoba, where manure applications would thus be permitted.

2.3.4.4 Manure Management Plans

Much of the value of the *Livestock Manure and Mortalities Management Regulation* results from the requirement for the completion of *Manure Management Plans*. Detailed requirements and the professional standards required for anyone preparing these plans are outlined in section 13. These plans provide Manitoba Conservation with extensive and useful information regarding the livestock operations of many agricultural producers in the province as follows:

13(1) No person shall store, handle or dispose of livestock manure, or apply livestock manure to land, except in accordance with a manure management plan registered with the director in accordance with subsection (4).

13(4) Before applying livestock manure to land as part of the fertilization program for a growing season, an operator shall submit a manure management plan for the growing season to the director for registration. The manure management plan shall be in a form approved by the director and shall contain or be accompanied by the information the director requires.

However, the detailed requirements associated with the preparation of a *Manure Management Plan* are not applicable for agricultural operators below the 300 animal unit threshold, as noted in section 13(3):

13(2) Subsection (1) does not apply to the operator of or a person employed in an agricultural operation that has less than 300 animal units on the day subsection (7) comes into force unless

(a) the operation is expanded after that day and the expansion results in the number of animal units in the expanded operation being 300 or more; or

(b) the director

(i) believes that the storage or handling of livestock manure in the operation, or that the land application of livestock manure in the agricultural operation, would likely

(A) cause pollution of surface water, groundwater or soil, or

(B) result in the livestock manure escaping from the boundary of the agricultural operation, and

(ii) notifies the operator in writing that subsection (1) applies to the agricultural operation for the period specified in the notice.

While Manitoba Conservation may well have concerns regarding the manure management practices of smaller livestock operators, the reality is that the ability to investigate these concerns is limited. Once again, smaller operators are exempt from an important provision of the regulation, with one result being a lack of data on manure spreading, land use, and associated risks to downstream water quality. It would seem logical for these management details to be collected from all livestock producers – via their *Manure Management Plans*.

Despite the known and significant nutrient runoff concerns associated with winter spreading of manure, at this point only the largest livestock operations (greater than 400 animal units) are prohibited from this management activity. Section 14(3.1) notes that this regulation will begin applying to operators above 300 animal units on November 10, 2010 – and to smaller operators in 2013, as noted in s. 14(3.2.).

2.4 The Drinking Water Safety Act and the Public Health Act

The Drinking Water Safety Act was given Royal Assent in 2002, but not proclaimed until 2004. Its main focus involved the creation of the Office of Drinking Water – with associated enforcement, inspection, ordering, and advisory powers regarding the operation of any public, semi-public, or private water supply systems (Manitoba Government Queen’s Printer 2002).

The Act is seen to be fairly innovative in its establishment of the Office as a central coordinating body for most aspects of drinking water safety protection. It also recognizes the fact that drinking water protection has occurred under the auspices of the Public Health Act since 1965, with three powerful regulations related to drinking water registered in 1988 (Simpson 2006 153-154). While outlining the duties of “drinking water officers,” the Drinking Water Protection Act also notes that “medical officers” have ultimate authority regarding public safety decisions related to water systems (s.11).

Section 28 of the Public Health Act outlines the many areas where the minister may make regulations, including those as follows (Manitoba Government Queen's Printer 1987):

- (p) respecting the construction, maintenance, cleansing, and disinfection, of drains, sewerage systems, sewers, sewage treatment plants, sewage disposal plants, and the location, cleansing, and disinfection of water closets, cess pools, septic tanks, privies, and other methods of disposing of sewage and waste;*
- (s) respecting the construction, maintenance, and purification, of water systems, and water supplies, including the testing and analysis of water therefrom, and the inspection and approval of sources of water supply; and*
- (t) preventing the pollution or fouling of wells, underground waters, and springs, and the cutting and storing of ice;*

In 1988, the Water Works, Sewerage and Sewage Disposal Regulation (MR 331/88R), the Water Supplies Regulation (MR 330/88 R), and the Protection of Water Sources Regulation (MR 326/88 R) all came into force, and remain in force currently. These three Public Health regulations form much of the legislative authority within the Drinking Water Protection Act.

MR 331/88 R addresses public safety related to public water and sewer systems generally managed by "sanitary districts" and "water districts." These districts are typically comprised of Manitoba municipalities, which are ultimately responsible for their operations (s. 10). Several sections of MR 331/88 R also make direct references to related and additional requirements of district operators under the Environment Act (s. 7.1, 9, 10, 11).

MR 330/88 relates to the responsibilities of water suppliers and public water system operators who offer potable water for domestic consumption. It also contains provisions regarding the responsibilities of private well owners to prevent groundwater contamination, both during well construction, use, and upon abandonment (s. 6).

MR 326/88 R contains several very clear prohibitions against the contamination of various type of source water bodies as noted within s. 2, where for example:

2.1 No person shall deposit or discharge into, or on to the bank of any river, stream, lake, creek, spring, coulee, reservoir, pond, or dugout, or on the ice thereof, any manure, excreta, filth, or refuse of any nature, or permit the fouling of contamination of ice or water on any such body of water by the congregating or watering of stock at any water hole or place.

2.2 No person shall commit any act that will or may contaminate any underground water supply by the discharge of any sewage, surface drainage, liquid waste, or filth into any well, abandoned well, hole, or other opening, and no person shall fill or replenish any existing well, except with water from an approved source satisfactory to the medical officer of health.

A new version of the Public Health Act has received Royal Assent (Manitoba Government Queen's Printer 2006). The minister's power to make regulations relating to water will be slightly revised as follows (s. 112.1):

(z) *respecting the construction, location, maintenance, cleaning and disinfection of drains, sewerage systems, sewers, sewage treatment plants, sewage disposal plants, privies and other wastewater management systems;*

(aa) *respecting the construction, provision, maintenance, operation and purification of potable water systems, and potable water supplies, including the testing and analysis of water and the inspection, approval and protection of sources of water supply;*

(bb) *respecting the pollution of wells, groundwater, surface water and springs, and the cutting and storing of ice;*

2.5 Conservation Districts and Watershed Planning

Manitoba's intensive agricultural settlement pattern, based on the township and range system, necessitated a means by which to control the flow of water and remove it from farmland, much of which is inherently wet.

The Red River Valley in particular, while extremely productive agriculturally is also very flat, with only 71m of relief over its 507km distance as it drains north toward Lake Winnipeg (Krenz 1993). Settlement and development of this region, both in Manitoba and the US states of Minnesota and North Dakota, set the stage for massive agricultural expansion of this region – through drainage.

2.5.1 The Conservation Districts Act

The conservation districts program in Manitoba was originally mandated in the *Watershed Conservation District Act* of 1959. The rationale for the *Resource Conservation Districts Act* of 1970 – and the ultimate repealing of both acts in 1976 are unclear. This may well have been associated with the turbulent nature of Manitoba's legislative assembly during this period.

Seven general elections occurred between 1958 and 1977 – representing the scope of potential political influence on the two (watershed and resource-focused acts). General elections occurred in: 1958 (June 16), 1959 (May 14), 1962 (December 14), 1966 (June 23), 1969 (June 25), 1973 (June 23), and 1977 (October 11).

The current Manitoba Conservation Districts Act was passed in 1976, and is designed to create partnerships between the provincial government and rural municipalities. The districts are to implement programs that meet both local and provincial needs – with a focus on soil conservation and water management. The districts receive funding from both provincial and municipal sources, as discussed below.

Under the 1976 Act, the provincial cabinet can create CDs through an Order in Council. This may be done following an application from a municipality or municipalities, or it may

be initiated by the provincial government. According to section 7(7) of the current Act the Order in Council establishing the District must state (Manitoba Statutes 2007b):

- (a) *the boundaries of the district;*
- (b) *where applicable the boundaries of sub-districts into which the district may be divided;*
- (c) *the name of the district which shall be substantially in the words "The - - - Conservation District";*
- (d) *the works to be excluded from the jurisdiction, authority or control of the board;*
- (e) *the co-ordinator;*
- (f) *the schedule;*
- (g) *the effective date of the formation of the district; and*
- (h) *such other matters relating to the district as may be appropriate*

In the legislation, the coordinator is defined as: *a civil servant designated by the minister for the purpose of coordinating all services and administrative assistance to CDs.* This is normally the manager of the province's Conservation Districts Program.

The legislation defines the schedule as: *an Order in Council setting out*

- (i) *the upper and lower limits of the amount of money that a board may annually assess an included municipality, and*
- (ii) *the limitations of the borrowing powers of the board;*

While some of the earliest CDs were established along watershed boundaries, the majority of those existing today are based upon municipal boundaries. Internally, each CD is divided into various "sub-districts," and these are intended to be as watershed-based as possible, so that planning and program delivery tends toward implementation at the watershed level. The effectiveness of this approach is debatable.

On the one hand, municipal boundaries make CD formation easier, which is important. However, a lack of watershed focus (even when conscious planning and delivery attempts are made at the sub-district level), raises the question of CD effectiveness in their attempts to address water-related challenges in a coordinated manner.

The formation of the earliest conservation districts (Whitemud, 1972; Turtle Mountain, 1973; Turtle River, 1974; Alonsa, 1978; and Cooks Creek, 1979) represent a mix of watershed-based and municipal boundary-based corporations which have experienced the greatest range of policy instrument rules and instrument delivery mechanisms associated with Manitoba's Conservation District Policy. In doing so, these five CDs have also forged the path for successive CDs to follow and learn from.

2.5.2 Conservation Districts Commission

It is critical to recognize the central and historical role played by the Conservation Districts Commission (CDC), an interdepartmental advisory body to the Minister. The CDC has been in place since the earliest CD-related legislation established it in 1959.

The CDC provides guidance on policy and financial matters, including recommending annual provincial budget contributions for each district and the program as a whole. This opportunity for the provision of key policy recommendations is very important, as it represents the only source of documented historical reference regarding many policy decisions for the CD program.

The need and importance of this function was recognized as early as 1959, has been strengthened over time, and remains in place to this day. In its initial form, the CDC was comprised of director-level representatives from rural-related provincial departments such as Natural Resources, Agriculture, and Highways. It was initially chaired by the director of water resources.

Today, the CDC is chaired by the deputy minister of Manitoba Water Stewardship and is comprised of deputy ministers from four additional departments (responsible for agriculture, conservation, intergovernmental affairs, and transportation). It includes representatives from the Association of Manitoba Municipalities, the Manitoba Conservation Districts Association, and a public appointee. Recent legislation has also been enacted to increase this public representation.

Through the advisory role played by the Conservation Districts Commission (CDC), the government controls the financial and administrative capacity of CDs. The CDC also provides policy guidance to all CDs, through a series of *Policy Directives* approved by the minister of Manitoba Water Stewardship and coordinated by the CD program secretariat with staff support.

However, its potential to play a central and long-term planning role for the CD program appears to have been underutilized in recent years, although this may prove to be extremely valuable in the future. The CDC is one of the few existing opportunities for effective interdepartmental planning and cooperation among Manitoba government departments which have responsibilities related to sustainability and natural resources management.

2.5.3 Range of Programs

By 1990, a flexible suite of CD programs had developed – with each CD delivering several activities in common with other districts in the program, and typically one or two programs somewhat unique to their own district. All CD budgets and a detailed list of planned program activities are reviewed annually – for ministerial recommendation – by the Conservation Districts Commission.

The older, watershed-based CDs have always devoted a significant portion of their annual budgets to drain maintenance and road crossing activities, notably Whitemud and Turtle River. Due to the nature of its low-lying landscape and dominance of agriculture in the area, Cooks Creek formed largely on the basis of drainage need. Alonsa assumed a degree of drain maintenance and crossing responsibilities through several agreements with the provincial water resources branch. Turtle Mountain does not have provincial drainage responsibilities given its initial formation as a *Resource Conservation District*.

Pembina Valley and all subsequent CDs were established without responsibility or authorities associated with the provincial drainage system. Beyond the complexities of drainage and water management, the range of CD programming by 1990 included the following (not all programs offered by all CDs):

<u>Soil and Water Conservation</u>	<u>Wildlife and Habitat Programs</u>	<u>Education Programs</u>
Creek/Gully Stabilization	Conservation Program	Conservation In Schools
Creek Maintenance	Fisheries Enhancement	Conservation Family Award
Grassed Waterway Seeding	Habitat Acquisition	Youth speaking events
Road Allowance Seeding	Land Donations	
Rotational Grazing Mgmt.	Tree planting/Shelterbelts	
Stone Crossing Installation	Agro-Forestry	
Water Quality Testing		

With the availability of additional program funding for new district formation, several new CDs were created during the 1990s (West Souris River, 1995; Upper Assiniboine, 1996; Intermountain, 1997; Little Saskatchewan, 1999; and Kelsey, 1999). Several of these new CDs formed in concert with the termination of a major federal/provincial agreement on agricultural sustainability – which saw ongoing program and technical staffing support provided to local farming associations interesting in demonstrating sustainability options.

During the 1990s, the Manitoba Conservation Districts Association became more formalized, better funded, and more professional – towards playing an increasingly credible role in representing all CDs in a unified manner in discussions with government and other stakeholders. Major improvements in annual conference attendance, sponsorship funding, communications, and policy/initiative negotiations occurred, evidenced by the drafting of favourable conservation agreement legislation and the negotiation of a GIS program royalty arrangement with a private software firm and the provincial government.

None of these newer CDs were interested in assuming any significant drainage or road crossing responsibilities, opting for more of an agricultural sustainability focus – stemming largely from their origins as previous local farm associations. By 2001, a variety of new CD programs included the following: many of these initiatives were gradually adopted by all other CDs in the program and Alonsa has initiated innovative working relationships with local First Nation communities (primarily through sacred site identification/interpretation:

<u>Soil and Water Conservation</u>	<u>Wildlife and Habitat Programs</u>	<u>Education Programs</u>
Small Scale Water Storage Abandoned Well Sealing Remote Cattle Watering Salinity Seed Program	Conservation Agreements Riparian Stewardship Ecotourism	Interpretive Sites Program Adult Education Workshops Holistic Pasture Management Check Strip Crop Demos.

Continued strong provincial promotion and support for the CD program – combined with a lack of substantial funding alternatives for both local farm associations and municipal councils saw continued program expansion into the new millennium (Lake of the Prairies, 2001; Tiger Hills, 2001; Seine-Rat River, 2001; Mid-Assiniboine, 2002; La Salle Redboine, 2002; East Interlake, 2005; and Swan Lake, 2006.

However, some of these latest additions to the CD program (and indeed some CDs created during the late 1990s) appear to be having difficulty focusing on an ideal mix of local programs of interest to local landowners and local municipalities. Several have experienced high staff turnover and few have developed management plans to guide their operations.

Also, several of these later generation CDs were established by a relatively small group of rural municipalities (and in two cases without the participation of logical adjacent municipalities). Merger discussions are being considered in at least one case. Most of the later generation CDs have included many towns and villages among their partners – building important urban/community connections and raising valuable additional operations revenue.

2.5.4 Performance Measurement

The CD program does not contain significant provisions for scientific monitoring and progress evaluation. Annual reporting for the overall program is largely a factual outline of activities occurring within each CD, accompanied by an audited financial statement. While CD boards report both formally (at an annual general meeting) and informally through regular contact with local stakeholders (often done through the publication of meeting minutes in local newspapers), there is no specific performance measurement framework on which to defensibly evaluate and improve the Manitoba CD program.

Budget-based financial reporting and annual program review does occur though the Conservation Districts Commission and additional pre-budget consultations with several CD program partners, while the program is subject to annual review by the provincial legislature.

However, there are gaps in linking annual CD programs to long-term management plan goals based on locally identified needs combined with provincial policy objectives. Using progress indicators to monitor annual progress would provide an important feedback

mechanism for adapting to changing conditions over time. This step could occur at both the provincial level (is the program fulfilling its goals?), and at the individual CD level (is the CD implementing its plans and fulfilling its goals?).

A suite of scientific indicators related to watershed health should also be developed – for province-wide application. Such a system would provide clear direction to guide CD management responses to observed indicator trends.

2.5.5 Interrelated Challenges of Drainage and Conservation

In several cases, the Manitoba CD program is designed to facilitate land drainage in response to local agricultural needs, and/or in place of municipal and provincial land drainage responsibilities. From a sustainable development viewpoint, drainage can be problematic – allowing rapid run off rather than a slower pace which allows for more infiltration of surface water into the ground. In more steeply sloped areas, this can result in a higher risk of flooding and infrastructure losses downstream. Increased streambank erosion and sedimentation can also result, increasing downstream drain maintenance costs.

However, agricultural drainage is a fundamental economic reality in much of the province, particularly in its relatively flat Red River Valley, as well as in many other southern areas where highly productive soils are inherently wet.

Unfortunately, substantial wetland drainage and loss has also occurred in Manitoba, and Manitoba CDs have been relatively powerless to stop it – a dichotomous and difficult challenge to reconcile when CDs may have both drainage and conservation responsibilities. In addition to associated wildlife habitat and biodiversity losses, wetland drainage reduces natural water retention/flood control capabilities and eliminates an impressive range of water quality services provided by these ecosystems.

Increased rates of drainage (while desirable from an agricultural production perspective) also tend to increase the flow of pollutants and nutrients – mainly from agricultural runoff – into downstream rivers and lakes. This is especially a problem for Lake Winnipeg, which is heavily stressed due to nutrient loads from many sources.

Much of Manitoba's landscape is inherently wet, including its productive southern agricultural soils. Consequently, water management challenges have existed in Manitoba since the province's agricultural settlement period. In response to the needs and demands of Manitoba's rapidly increasing population of rural agricultural families, provincial-municipal agricultural drainage schemes were a major focus from 1895 to 1935, during which two million acres of prime agricultural land were supported with infrastructure through the creation of "drainage districts." Subsequent additional peaks of activity occurred into the 1970s, largely with federal government support.

While increased agricultural drainage made more land viable for annual crop production, according to Ogrodnik (1984), a number of long-standing and recurring drainage-related concerns routinely influenced local politics and provincial policy. These remain relevant today and include:

- 1) “Foreign water” (water flowing into other areas from upstream) has regularly plagued the owners of lowland agricultural areas and the downstream rural municipalities who govern these lands;
- 2) Strong perceptions exist that foreign water problems occur and become worse because of upland drainage, land use changes (including clearing of forested lands), and road construction; and
- 3) Suggestions are regularly made that owners of upstream land (and rural municipalities pay a portion of lowland water management costs.

Predictably, these concerns are more prevalent during and following periods of relatively wet growing seasons. They are prevalent in current public policy debates, particularly following record rains received in Manitoba, and across the Canadian Prairies, during the peak growing period of 2005. Increased technological efficiency has also made new on-farm drainage easier to undertake, often at lower cost than earlier methods.

In attempting to understand and address emerging “foreign water” problems associated with increased agricultural drainage, the Province of Manitoba conducted several intense investigations, beginning in 1918. As reported by Ogrodnik (1984), these commissions of inquiry gradually assisted in defining and clarifying Manitoba’s surface water management challenge – eventually leading to formulation of Manitoba’s Conservation District Policy and Act in 1976. A summary of these commissions’ findings and other interrelated policy trends to the present-day is provided in Chart 2-1.

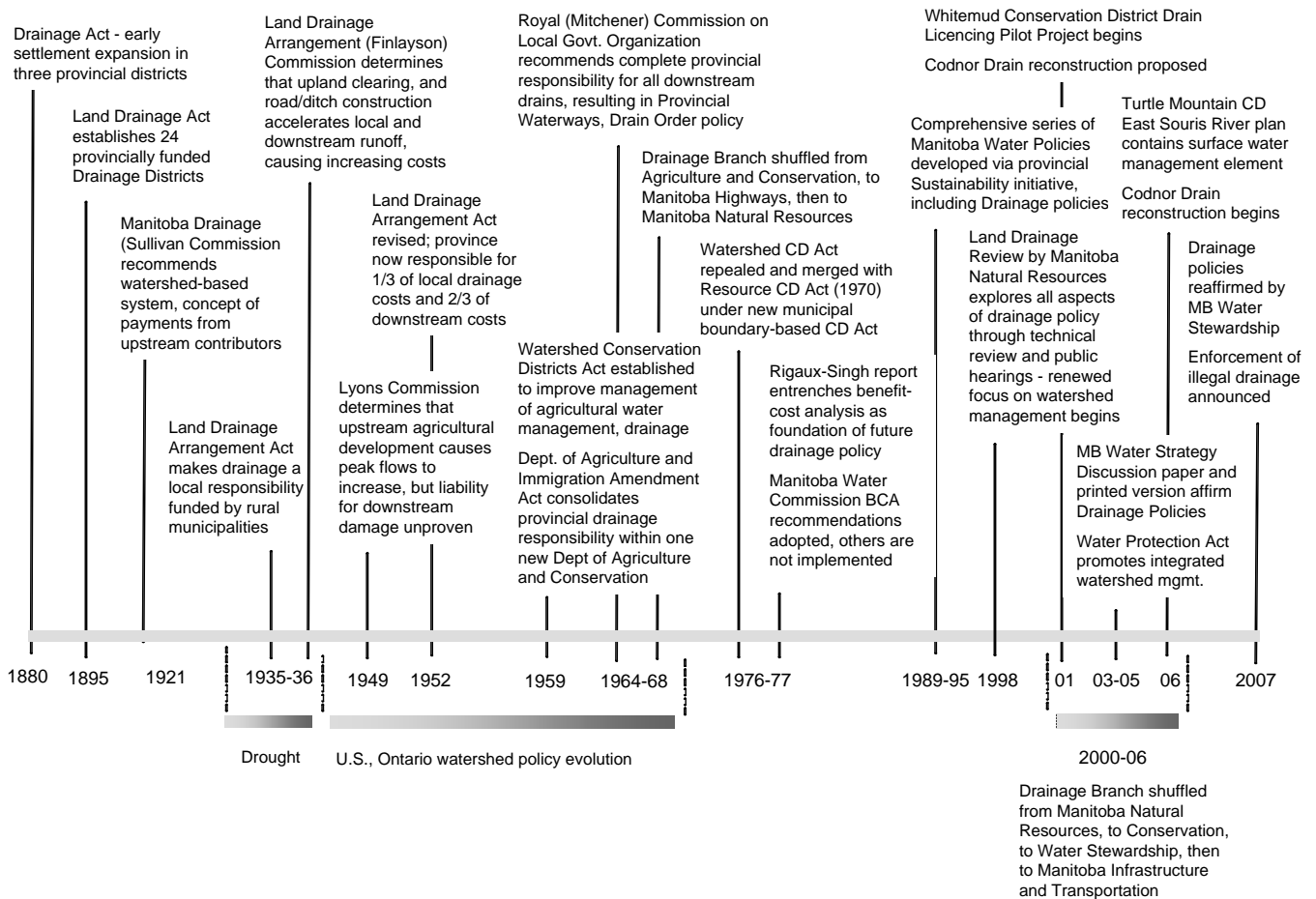


Chart 2-1: Manitoba Drainage Policy Timeline

The Manitoba Watershed Conservation Districts Act of 1959 is particularly interesting and relevant. It appears this act may have represented the vanguard of public water management policy at the time (recognizing the importance of watershed-based solutions). However, it was repealed in 1976.

In fact, Manitoba’s watershed focus for resource management began to dissipate as early as 1970, with the passage of the *Resource Conservation Districts Act*. Early CDs were formed under both forms of legislation: Whitemud and Turtle River were formed under the 1959 watershed-based legislation, while Turtle Mountain was formed under the 1970 resource legislation. Both early acts were repealed and merged into the current version, in 1976.

Ontario’s conservation authority legislation (which is watershed-based) was enacted in 1946, enabling the eventual formation of 36 local corporations which today spend \$158 million annually on watershed management solutions through a local-provincial cost-shared partnership (Conservation Ontario 2006). Their role and budgetary importance has increased dramatically in response to the Walkerton Inquiry recommendations as key policy delivery agents for the province.

A decade earlier, the U.S. Flood Control Act was passed by Congress in 1936, signalling clear federal responsibility for water resources management (Allee 1987). Based on the apparent multi-purpose success of the Tennessee Valley Authority, federal support would be provided for watershed-based projects for which “the benefits to whomsoever they accrue are in excess of estimated costs,” marking the beginning of watershed evaluation (Galloway 1987).

Allee (1987) points to the early management concepts advanced by Gilbert F. White (1957) as the first “pure doctrine” of integrated watershed planning, management, and development – citing three ideas (multi-purpose storage projects, basin-wide programming, and comprehensive regional development) and two concepts (articulated land & water programs and unified administration) which characterize an effective watershed approach.

By the early 1960s, scientists recognized “the watershed” as a sensible framework within which to address interrelated problems such as water quality and contamination. The approach of “taking the whole watershed into account” emerged as an efficient and practical means of tackling these issues with the support of science. In tracing this evolution, Heindl (1972) notes two pervasive concepts founding the discipline:

- 1) The watershed is a closed system which integrates the physical forces which act upon it; and
- 2) The knowledge and experience gained through the study of one watershed is transferable and thus, may be applied extensively elsewhere (and concentrated, small basin study is applicable to larger ones).

Manitoba’s 1959 watershed-based CD legislation was drafted following earlier legislative experiences in Ontario and the United States, at the dawn of the emergence of a new scientific discipline focused on watershed planning and management solutions. Manitoba had a timely opportunity to learn from these leading policy and scientific trends – and lead with new innovations. Unfortunately, the early opportunity was lost.

2.5.6 The Current Status of IWRM in Manitoba

In 2005, the International Institute for Sustainable Development (IISD) conducted an extensive policy review of the Prairie Water Region. *Prairie Water Strategies: Innovations and Challenges in Strategic and Coordinated Action at the Provincial Level* (Swanson 2005) utilized an analytical framework based on the IWRM Management Cycle developed by the Global Water Partnership (GWP), which articulated Integrated Water Resources Management (IWRM) as:

“a process which promotes the co-ordinated development and management of water, land and related resources in order to maximize the resultant economic, social welfare in an equitable manner without compromising the sustainability of vital ecosystems” (Jøynch-Clausen 2004)

Watershed planning initiatives are now underway in several conservation districts, notably in the Pembina Valley, Turtle Mountain, and West Souris River Conservation Districts. IISD has been monitoring these plans as they evolve, and has conducted a detailed review of the IWRM plan prepared by the Turtle Mountain CD.

By analyzing the plans of leading watershed institutions – as the most tangible and structured evidence of provincial water policy in application, important clues regarding each province’s IWRM progress can be elucidated. To study strategic and coordinated action for water resources at a provincial level, IISD has been utilizing a simplified version of the GWP IWRM cycle articulated by Jønych-Clausen (2004) as illustrated in Figure 2-3. Included are:

Leadership (e.g., commitment through a strategy, focus through articulated goals and objectives);

Planning (e.g., departmental structure, inter-departmental planning, commitment to watershed planning and management) and **Multi-level Coordination and Participation** (e.g., coordination within a strategy process and among jurisdictions, and engagement of key stakeholders throughout the strategy process); and

Implementation (e.g., responsibility, financing and leveraging a mix of policy instruments);

Monitoring, Evaluation and Improvement (e.g., indicator monitoring, formal and informal evaluation and improvement processes).

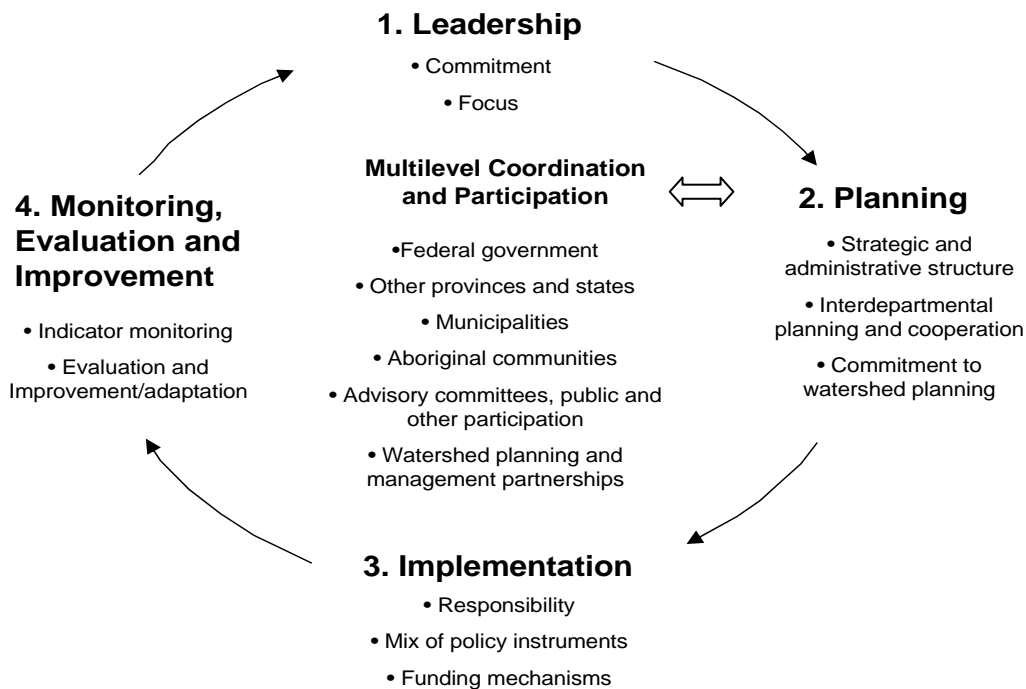


Figure 2-3: Prairie IWRM analytical framework
Source: Swanson 2005

2.5.6.1 IWRM in Manitoba: East Souris River Watershed

The Turtle Mountain Conservation District (TMCD 2006) began initial plans toward its Integrated Watershed Plan in 2002. The TMCD Board invited a variety of local stakeholders to participate in the process, and this group evolved into a Watershed Planning Advisory Team (WPAT). The *East Souris River (ESR) Integrated Watershed Plan* was finalized and adopted by Manitoba Water Stewardship as the province's first official IWRM plan in 2006.

Use of the Watershed Planning Advisory Team (WPAT) model, involving the provision of technical support from several provincial departments and other agencies – in addition to a coordinating group from the conservation district – appears to now be the standard format for IWRM planning in Manitoba. Based on a detailed analysis of the ESR plan, a draft overview of IWRM progress in Manitoba is provided in Table 2-1.

2.5.6.2 Conclusions

The ongoing debate over agricultural drainage at all levels (on-farm, locally, and regarding provincial drains), is indicative of serious problems with the decision-making framework for surface water management. While the CD program itself was originally intended to directly address Manitoba's drainage challenge, it has effectively become another forum for discussion, demonstration, and awareness in the search for coordinated, watershed-based landscape and community solutions related to agriculture and natural resources.

Manitoba's CDs are caught in the drainage struggle between farmers, rural municipalities, and the province. In responding to the surface water management dilemma, some CDs are attempting to find workable approaches to managing surface water – by outlining clear plans and relative responsibilities for all drainage stakeholders. However, with a lack of resources and clear decision-making responsibilities (among all stakeholders), expectations that a solution will emerge anytime soon must be considered ambitious if not unrealistic.

The fact that most CDs are not formally or legally defined on watershed boundaries leads to several management problems. The “functional area” on which most CDs are administratively designed is not consistent with the natural systems the CDs are trying to manage effectively. Most CDs do not have authority over all of the contributing headwater areas – or all collecting waterways downstream. As a result, many more stakeholders than necessary must be engaged for any surface water management plan to be effective, and this consumes valuable time and precious resources.

When the 1959 watershed-based version of the CD Act was repealed– in favour of a municipal boundary-based framework – the stage was set for a continued struggle over all aspects of land drainage in Manitoba, a struggle which continues today.

Manitoba's CDs are now being expected to play a central role in addressing the challenge of declining water quality in Lake Winnipeg (Manitoba Government 2007). This challenge was not foreseen as a CD responsibility during initial program design. At this point, Manitoba's CDs are not adequately prepared to meet this challenge.

There is a need for substantial reallocation of existing human, technical, and financial resources – resources which abundantly exist through the ongoing work of numerous provincial government departments and programs. These existing efforts and initiatives are focused on a myriad of activities which may be easily demonstrated as highly relevant and related to the logical governance, implementation, and performance measurement objectives of an ideal IWRM framework for Manitoba.

Dealing with Lake Winnipeg's water quality will face the same challenges as surface water management: a lack of clear decision-making authority among several stakeholders; a lack of resources at all levels; and the fact that most CDs do not function within complete watershed boundaries. In terms of the Lake Winnipeg challenge, a lack of coordinated planning and management throughout its huge watershed (across multiple and complex political jurisdictions) is also recognized as a critical influencing and limiting factor.

There have been at least eight major reviews of Manitoba drainage policy since the agricultural settlement period. Through decades of study and several Provincially appointed commissions, various aspects of the watershed management challenge have gradually become more clearly defined.

The roots of these complications and problems are found in the establishment of a system which, from 1895 to 1935, brought about the drainage of two million acres of natural inherently wet but extremely fertile land for agricultural development – without an effective long-term plan for surface water management or water quality protection.

While the current CD Act enables and encourages local decision-making in support of soil and water conservation, the ultimate authority for surface water drainage largely lies with the Province of Manitoba, as does the challenge of Lake Winnipeg water quality. However, the support of other partners – including the federal government, municipalities, and individual landowners and other citizens will be required – if measurable progress is to be achieved.

Table: 2-1: Overview of IWRM Progress in Manitoba: East Souris River Watershed Plan

	Leadership	Planning, Coordination, and Participation		Implementation	Monitoring, Evaluation, and Improvement
		Provincial Planning	Multi-level Coordination and Participation		
<p>Manitoba East Souris River Watershed</p>	<p>Strong local leadership has propelled the ESR plan, including strong local commitment to key guiding principles as a foundation for the plan.</p> <p>The provincial WPAT process was not in place before the TMCD initiated IWRM efforts; the WPAT model evolved with this first plan.</p> <p>Broad, locally-driven goals are supported with specific objectives, target areas, timelines, and budgets.</p> <p>Less priority is placed on federal-provincial policy or other NGO and private funding priorities vs. local needs; this may represent a funding challenge in terms of plan implementation.</p> <p>ESR is the first and only IWRM plan to be adopted by MB Water Stewardship.</p> <p>Some important SD areas not addressed (i.e. climate change, economic, social).</p>	<p>The ESR plan contained strong departmental participation on the WPAT, with coordination assistance from DUC.</p> <p>While a secretariat exists to support the development of new conservation districts in Manitoba (which are central to IWRM planning), there are limitations on its ability to support CDs in their watershed planning processes or to coordinate WPAT participation and/or intergovernmental roles.</p> <p>Manitoba departments of Finance and Health were not involved in the ESR plan.</p> <p>The Manitoba Conservation Districts Commission (an interdepartmental body), could and should play a larger role in providing IWRM direction.</p> <p>The CD program provides a solid foundation for IWRM planning, but most CDs are not watershed-based at this time.</p> <p>There is little provincial support for alternatives to the CD-led model, although legislation permits this – a lost opportunity for experimentation and new forms of knowledge generation.</p>	<p>Only the municipal-based CD program is recognized by the province for the development of IWRM plans via Watershed Planning Adv. Teams (WPATs), although other groups do exist.</p> <p>Ideal federal IWRM support roles are not clear, although some departments (AAFC, EC, FOC) have major funding, monitoring, and/or regulatory impacts.</p> <p>Significant portions of the ESR watershed are located in other jurisdictions (ND and possibly SK), although these jurisdictions did not participate in the plan.</p> <p>Manitoba’s CD program ensures strong municipal participation in IWRM initiatives, but RMs can dominate the process and may not demographically represent the watershed community as a whole.</p> <p>The lack of industry participation suggests the ESR plan may be quite limited in its scope in terms of sustainable development.</p> <p>Aboriginal participation was non-existent, suggesting the magnitude of this IWRM challenge.</p> <p>There is a need to engage more women/youth in IWRM plans.</p>	<p>Effective IWRM requires the coordinated and focused actions of a large number of landowning residents within a watershed/subwatershed. This is a new role for the conservation districts.</p> <p>ESR target areas include specific subwatersheds or headwater regions, but no structured means to focus or facilitate and/or fund this participation and progress.</p> <p>Clear responsibilities are outlined for WPAT members, but firm commitment levels or pledges are not defined.</p> <p>There is a balanced mix of instruments in the ESR plan, containing a strong focus on economic incentives, including EG&S payments – outlined within three plan objectives.</p> <p>Various stages of budget readiness exist to implement the plan, while funding costly incentive programs will be a challenge.</p> <p>There is a need to develop innovative mechanisms for financing the IWRM plans.</p>	<p>A coordinated data collection and analysis system to establish baseline planning conditions and monitor watershed management progress has also been identified as a critical requirement for Manitoba CDs.</p> <p>All ESR plan objectives include general monitoring and evaluation plans, but budgets do not exist.</p> <p>Annual and Five Year Watershed Reports are planned for the ESR with a focus on water quality.</p> <p>MB Water Stewardship has yet to develop its State of Watershed framework or protocols, and there is a lack of monitoring infrastructure.</p> <p>The ESR plan is to be reviewed every five years, with some “watershed health” performance indicators to be developed.</p> <p>There may be accuracy and quality-control concerns with locally collected data.</p>

2.6 A Watershed Planning/Performance Model from Saskatchewan

The Saskatchewan Watershed Authority (SWA) is primarily responsible for the management of Saskatchewan's water resources, while the Saskatchewan Environment department coordinates the *Safe Drinking Water Strategy* and serves as a regulator and standards setting agency. The SWA reports to the Minister of Saskatchewan Environment and comprises an Operations division responsible for management of surface and groundwater, and a Stewardship division that provides watershed monitoring/assessment services and watershed/aquifer planning support to communities.

SWA-initiated watershed management plans take the form of Source Water Protection Plans. The Source Water Protection Plan for the Lower Souris River (LSR) was the first of its kind, and was released in March 2006 (SWA 2007). This plan and affiliated documents, including an action plan for the Lower Souris by the Lower Souris Watershed Committee (LSWC 2007) and the State of the Watershed Report from March 2007 are analyzed for the purposes of this research.

The SWA (Stewardship Division) was largely responsible for the watershed plans and the watershed committees that made the LSR plan possible. Significant provincial funding initiated the watershed plans and their implementation. Additionally, The Safe Drinking Water Strategy (SDWS) is one of the province's first *Key Cross-Government Strategies* developed under Saskatchewan's *Interdepartmental Planning Guidelines*, part of a government-wide "managing-for-results" initiative.

Six provincial government departments participated in developing the LSR plan, including those relating to environment, agriculture, industry, health, government relations, and the SWA. Key Cross-Government Strategies are deemed to have province-wide importance, "transcending the mandate of any one department and necessitating a collaborative effort among two or more departments and/or agencies to achieve more meaningful results." Saskatchewan's *Interdepartmental Planning Guidelines* apply to interdepartmental initiatives that are "strategic, collaborative, and directly related to government priorities" (Saskatchewan Finance 2007)

Saskatchewan released its State of the Watershed Reporting Framework in January 2006 and subsequently its first State of the Watershed Report Card in March 2007. This report card uses indicators to assess the current health of Saskatchewan's watersheds, provide information about human activities that impact the environment within watersheds, and evaluate the effectiveness of the management activities. The indicators include "condition indicators such as water quality and quantity based indicators, riparian buffer indicators, "stressor indicators" including human populations, roads, water use and water allocation, and "response indicators" including water conservation and water education based indicators. Monitoring and management of water quality and water quantity are also included in the response indicators.

Annual reporting processes via Saskatchewan Finance Department accountability frameworks is advanced. Evaluation processes are in place in Saskatchewan via a steering committee for the Safe Drinking Water Strategy, which is comprised of deputy ministers, is responsible for the annual review of the strategy. While Saskatchewan has released its first State of the Watershed Report Card in recent months (March 2007), follow-up management actions on regions identified as stressed or impaired on the basis of these indicators is yet unclear, although the challenge to local watershed organizations is clearly implied.

3 Review of Provincial Planning Legislation

3.1 The Planning Act

The *Planning Act* has undergone a number of significant revisions since its first adoption in Manitoba (1916). It is a very substantial and significant piece of legislation, which governs local decision-making throughout the province. Manitoba's Rural Municipalities have utilized its provisions extensively since the 1950s (Manitoba Intergovernmental Affairs 2007)

3.1.1 Provincial Land Use Policies

Part 2 refers to *Manitoba Provincial Land Use Policies* which may be established by regulation "to guide sustainable land use and development in the province" (Manitoba Statutes 2005). These policies serve as much of the foundation for the *Planning Act* and are articulated in detail within the *Provincial Land Use Policies Regulation* (MR 184/94, along with amendment MR 193/05 (Manitoba Statutes 1994). While they are basically "planning guidelines," these policies set the tone for the development decisions made by local authorities throughout the province, and several have significant implications for water quality, water quantity, resources management, and agriculture.

Of note are policies 2, 4, and 7 which have direct linkages to the management of agricultural watersheds. Policy 2-Agriculture has the following objectives (Manitoba Statutes 1994):

1. *to maintain a viable base of agricultural lands for present and future food production and agricultural diversification;*
2. *to protect agricultural operations from encroachment by other land uses that may adversely affect the ability of a producer to efficiently manage, expand or diversify an operation;*
3. *to foster the use of land that is consistent with the Principles and Guidelines of Sustainable Development and encourages the sustainable use of the resource base for agricultural production.*

In terms of policy application, a number of additional planning guidelines are also included within the regulation. One of these is in fact now a requirement – that all local authorities must incorporate a "Livestock Operation Policy" into their development plans by 1 January 2008. As noted in Policy 2-Agriculture (s.6), a Livestock Operation Policy is to account for:

- (a) *soils;*
- (b) *the size of a livestock operation, based on the number of animal units in the operation;*
- (c) *proximity to significant surface water bodies, such as lakes, rivers and wetlands;*
- (d) *flood risk areas identified by the province;*
- (e) *groundwater vulnerability areas identified by the province;*
- (f) *proximity to areas designated in the development plan as*
 - (i) *urban centres or settlement centres,*
 - (ii) *rural residential or seasonal residential areas, and*

(iii) parks or recreational areas; and

(g) existing land uses in the area.

Policy 4-Water and Shoreland seeks to (Manitoba Statutes 1994):

1. to maintain and manage land and water resources to meet important needs including: the domestic water supply, recreation, tourism, flood and erosion protection, bank stability, water table retention, waste assimilation, irrigation, hydro-electric power generation, heritage resource preservation, and to ensure the viability of critical flora and fauna habitat; and

2. to support use, development of, and access to the province's waterways, water bodies and shoreland where appropriate.

This policy also provides extensive policy application guidance regarding the means by which water and shoreland areas may be protected through sound development planning:

1. Land should be developed in a manner which ensures that waterways, water bodies

groundwater and shoreland having environmental, economic, recreational, fishery or cultural significance are sustained.

2. Waterways, water bodies, shoreland and groundwater requiring protection shall be identified. The type and extent of protection afforded to the waterway, water body, shoreland or groundwater will depend upon local circumstances including the size and configuration of the water body, waterway, shoreland or groundwater, the need for public access, environmental characteristics, and economic potential.

3. Shoreland reserves or parks may be created by local authorities or the Province to protect shoreland, waterways and water bodies. Where appropriate, public acquisition may occur by direct purchase, dedication through the subdivision approval process, easement or lease. The amount of land acquired and the provision of access to the shoreland, waterway or water body shall be designed to suit the local situation.

4. Development shall occur in a manner which sustains the yield and quality of water from significant aquifers.

5. Ground water pollution hazard areas identified by the Province should be taken into account in land use plans at the provincial and local levels. Provisions required to safeguard such areas should be applied through these plans in respect of land uses and structures such as wells, commercial chemical or fertilizer storage facilities, septic systems, fuel tanks, waste disposal grounds, lagoons that store or treat substances that are potential pollutants, and other uses or structures that could potentially pollute groundwater.

Policy 7-Flooding and Erosion recognizes the interconnected nature of land use and downstream water management while also attempting to (Manitoba Statutes 1994):

1. to minimize property damage and public expenditures for flood relief or protection;

2. to enhance sustainability by managing development in order to minimize personal hardship and inconvenience, adverse effects on property and danger to public health and safety due to flooding and erosion;

3. to restrict development or land use that would accelerate or promote environmental damage arising from causes such as erosion or bank instability;

4. to maintain the natural capability of waterways to convey flood flows; and

5. to restrict development or land use that could reduce the benefits derived from existing flood control works.

The following flooding and erosion policy application measures are also outlined:

(a) development shall not adversely alter, obstruct or increase water flow, flow velocities or flood levels. Development should be allowed only if the cumulative effect of all foreseeable development in the flood prone area is within water flow, flow velocity, or flood level limits that may be specified in regulations or by-laws for the area;

(b) there shall be no added risk to life, health, or safety;

(c) all structures and services shall be protected against damage and shall be functional under hazardous conditions;

(d) activities such as dumping, excavation and clearing, which accelerate or promote damage due to causes such as erosion or bank instability, shall be prohibited; and

(e) natural tree and vegetative cover shall be preserved to reduce erosion and assist in maintaining bank stability.

It is interesting to note that at least three *Provincial Land Use Policies*, relating to Agriculture, Water and Shoreland, and Flooding and Erosion have direct and clear relationships to rural land use and the hydrologic functions and impacts of flowing water within a natural drainage system. It is equally significant to note the strong connections to these policies – within numerous provisions contained within the *Water Protection Act* and the *Conservation Districts Act*.

3.1.2 Planning Districts and Individual Municipalities

Part 3 of the Act outlines the roles of *Planning Authorities*, which may be either: 1) an individual municipality, 2) a planning district, or 3) a planning commission. Prior to the 1970s, most rural municipalities considered proposed livestock operations within their boundaries as “conditional uses,” a term which has remained in use today – even with the evolution of the *Planning Act* in Manitoba – which has moved toward the use of *Development Plans* and *Zoning By-laws* since major revisions to the *Planning Act* in 1976 (Manitoba Intergovernmental Affairs 2007).

Since 1976, Manitoba’s Rural Municipalities have been encouraged to form *Planning Districts* in accordance with the Act (Manitoba Statutes 2005, s.14-30).

14 When a planning district is established, its board is responsible for:

(a) the adoption, administration and enforcement of the development plan by-law for the entire district;

(b) the administration and enforcement of

(i) the zoning by-laws of its member municipalities, or the district's own zoning by-law if it has adopted a district-wide zoning by-law under section 69,

(ii) any secondary plan by-law in force in the district,

(iii) the building by-laws of its member municipalities, and

(iv) the by-laws of its member municipalities dealing with minimum standards of maintenance and occupancy of buildings.

In the absence of a planning district, individual municipalities are responsible for the “adoption, administration, and enforcement of the development plan by-law, zoning by-law, and all other by-laws respecting land use and development for the municipality.” Another type of planning authority (a planning commission) may be formed by planning districts or individual municipalities to help address issues related to zoning variances and conditional use applications (s. 33)

3.1.3 Development Plans and Livestock Operation Policies

Either a planning district (or a municipality, if not a member of a planning district) must prepare a development plan to govern future land use decisions within its boundaries. Effective 1 January 2008, this plan must also contain a Livestock Operation Policy. The basic details of these requirements are outlined below. The development plan is adopted by by-law.

42(1) *A development plan must*

- (a) set out the plans and policies of the planning district or municipality respecting its purposes and its physical, social, environmental and economic objectives;*
- (b) through maps and statements of objectives, direct sustainable land use and development in the planning district or municipality;*
- (c) set out measures for implementing the plan; and*
- (d) include such other matters as the minister or the board or council considers advisable.*

42(2) *The development plan must include a livestock operation policy that guides zoning by-laws dealing with livestock operations by*

- (a) dividing the planning district or municipality into one or more areas designated as follows:*
 - (i) areas where the expansion or development of livestock operations of any size may be allowed,*
 - (ii) areas where the expansion or development of livestock operations involving a specified maximum number of animal units may be allowed,*
 - (iii) areas where the expansion or development of livestock operations will not be allowed; and*
- (b) setting out the general standards to be followed in the planning district or municipality respecting the siting and setback of livestock operations.*

Also of note is the following section – in which a planning district or municipal council must consider relevant aspects of the *Water Protection Act* in the preparation of a development plan. However, it is equally interesting to note the guidance provided by s. 191 below.

62.1 *When preparing a development plan or amending or re-enacting a development plan by-law, a board or council must consider the application of the following insofar as they relate to land within the planning district or municipality:*

- (a) any regulation made under section 4 of The Water Protection Act governing, regulating or prohibiting any use, activity or thing in a water quality management zone designated under that Act;*
- (b) any watershed management plan approved under The Water Protection Act.*

191 *Where there is a conflict between a provision of this Act and a provision of The Conservation Districts Act, the provision of this Act prevails.*

To date, all watershed management plans formally initiated under the auspices of the *Water Protection Act* have been coordinated by Manitoba's Conservation Districts, as local *Water Planning Authorities* approved by the Minister of Water Stewardship. It is logical that a development should incorporate relevant aspects of a watershed management plan, but the fact that the *Planning Act* so clearly overrides the *Water Protection Act* should be of significant concern.

3.1.4 Conditional Use Decisions and Technical Review Committees

A “conditional use” is defined as “a use of land or a building that may be permitted under a zoning by-law (Manitoba Statutes 2005). Part 7 of the Planning Act outlines the requirements and general process for the review and/or approval of conditional uses by planning districts or municipalities.

For livestock operations under 300 animal units, a planning district or municipality cannot reject a development proposal, but as per s. 107(1), can only place conditions related to:

- (a) measures to ensure conformity with the applicable provisions of the development plan by-law, the zoning by-law and any secondary plan by-law;*
- (b) one or both of the following measures intended to reduce odours from the livestock operation:*
 - (i) requiring covers on manure storage facilities,*
 - (ii) requiring shelter belts to be established;*
- (c) requiring the owner of the affected property to enter into a development agreement dealing with the affected property and any contiguous land owned or leased by the owner, on one or more of the following matters:*
 - (i) the timing of construction of any proposed building,*
 - (ii) the control of traffic,*
 - (iii) the construction or maintenance — at the owner's expense or partly at the owner's expense — of roads, traffic control devices, fencing, landscaping, shelter belts or site drainage works required to service the livestock operation,*
 - (iv) the payment of a sum of money to the planning district or municipality to be used to construct anything mentioned in subclause (iii).*

As denoted in s. 107(2), a planning district or municipality cannot place any conditions “respecting the storage, application, transport, or use of manure from a livestock operation described in 107(1), other than a condition permitted under clause (1)(b).”

Larger livestock operations (above 300 animal units) are dealt with via a separate process, typically involving consideration of a development proposal by a *Technical Review Committee* comprised of several applicable departmental representatives. As per s. 113(4), this committee provides a report with recommendations regarding the development application. The report is public and is provided as advice to the planning district or municipality (or planning commission) in advance of a public hearing to review the proposal.

116(1) *After holding the hearing, the board, council or planning commission must make an order*

(a) rejecting the application; or

(b) approving the application if

(i) the Technical Review Committee has determined, based on the available information, that the proposed operation will not create a risk to health, safety or the environment, or that any risk can be minimized through the use of appropriate practices, measures and safeguards, and

(ii) the proposed operation

(A) will be compatible with the general nature of the surrounding area,

(B) will not be detrimental to the health or general welfare of people living or working in the surrounding area, or negatively affect other properties or potential development in the surrounding area, and

(C) is generally consistent with the applicable provisions of the development plan by-law, the zoning by-law and any secondary plan by-law.

The planning authority is again limited on the conditions it can impose if it chooses to approve the application. These include measures outlined in s. 116(2) related to development plan consistency, implementing Technical Review Committee (TRC) recommendations, and odour reduction efforts (manure storage covers and/or shelter belt planting). Section 116(3) again notes that the planning authority cannot include conditions related to manure storage, application, transport, or use.

Typically the TRC has included departmental staff from Manitoba Agriculture, Food and Rural Initiatives, Manitoba Intergovernmental Affairs and Trade, Manitoba Water Stewardship, and Manitoba Conservation. Despite some expectations to the contrary, the TRC process was not designed to serve as an environmental assessment. It is a general overview of the livestock development proposal and a cursory technical assessment of the project's potential impacts, along with recommendations on these can possibly be mitigated (Manitoba Intergovernmental Affairs 2007, Province of Manitoba 2006).

If a planning district or municipality decides to approve a livestock operation development, a number of provincial permits are required before the development can proceed. These include a manure storage permit and approval of the operator's manure management plan under the *Livestock Manure and Mortalities Management Regulation* of the *Environment Act* as well as a licence under the *Water Rights Act*. Figure 3-1 outlines this process.

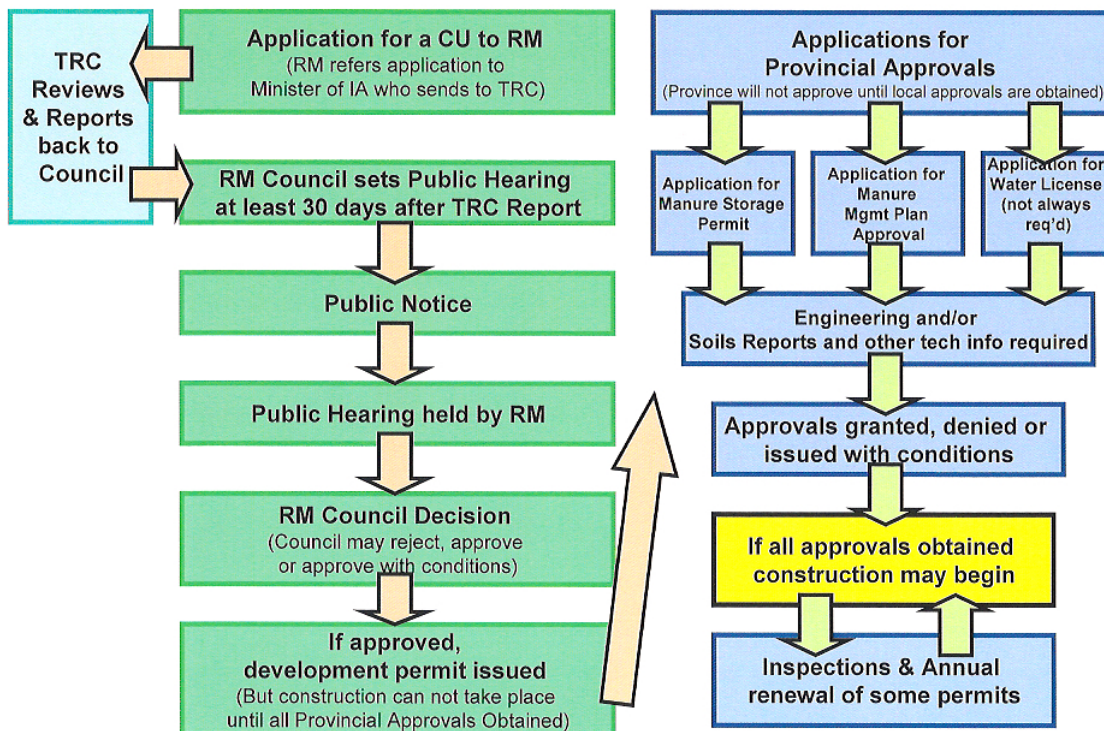


Figure 3-1: Current Livestock Operation Application Approval Process (300+ animal units)
 Source: Manitoba Intergovernmental Affairs 2007

3.2 Policy Review Findings

Considering the *Total Nutrient Loading Framework* developed in Task 1 of this research, a review of relevant provincial legislation was conducted, with a focus on the *Manitoba Water Strategy* and *Water Protection Act*; the *Environment Act* and *Livestock Manure and Mortalities Management Regulation*; the *Conservation Districts Act* and related challenges/innovations in *Integrated Water Resources Management*. Finally, the *Planning Act* was reviewed in detail with regard to its role in rural planning related to natural resources and the *Technical Review Committee* process related to hog industry development decision-making at the local level.

What became abundantly clear is that a provincial policy conflict appears to exist. This conflict is associated with the logic of having Manitoba's *Planning Act* responsible for at least three *Provincial Land Use Policies* (related to Agriculture, Water and Shoreland, and Flooding and Erosion) which are directly related to the planning and management of agricultural watersheds. Based on this legislation, either Planning Districts or Rural Municipalities, as local *Planning Authorities*, are to be responsible for planning related to these land uses.

However, under the *Conservation Districts Act*, Manitoba's Conservation Districts also have substantial responsibilities (and in fact were initially established) to assist in reducing agriculture's impact on downstream water bodies through a combination of *Total Land and Water Management* initiatives. While the historical performance of conservation districts in addressing these challenges is certainly debatable, the intent of the Act was clear, particularly with the initial 1959 legislation.

Furthermore, in February 2007 The Minister of Water Stewardship declared that the Lake Winnipeg Stewardship Board would be responsible for coordinating provincial nutrient management plans through Manitoba's Conservation Districts – implying a greatly expanded role for the conservation districts – in addressing the province's nutrient challenge (Manitoba Government 2007).

The fact that Manitoba's Conservation Districts are largely not watershed-based and are significantly under-resourced – both in their financial and technical capacity – does not suggest that they could not play an effective future role in addressing Manitoba's *Total Nutrient Loads*. The fact the *Planning Act* and Manitoba's Planning Districts expressly supercede the powers of the *Conservation District Act* and Manitoba's Conservation Districts reflects a serious lack of policy and practical understanding associated with the comprehensiveness and complicated elements which must be addressed through *Integrated Water Resources Management*.

Meaningful progress on Total Phosphorus Reduction or reducing overall nutrient loading will not occur until Manitoba's "Planning – Conservation Conflict" is addressed.

One means to address this conflict has been presented by Manitoba's *Water Protection Act*, which outlines the powers, roles, and responsibilities for local *Water Planning Authorities*, which are to prepare watershed management plans across the province. To date, all designated authorities are in fact the boards of Manitoba Conservation Districts, suggesting an important new role for these organizations is on the horizon.

However, both the technical capacity of conservation districts, applicable provincial departments (particularly Manitoba Water Stewardship), and the province in general, must be substantially increased if this role is to be fulfilled. It is equally clear that the Province of Manitoba must also step up its attention to addressing the *Total Nutrient Loading* challenge – by realizing the need for a *Cross-Government Strategic* approach to implementing Integrated Water Resources Management on a province-wide scale, with the full resources and technical capacity of all relevant departments.

Finally, given the apparent legislative duplication which exists among some elements of the reviewed policy, there are real opportunities to streamline several aspects of provincial decision-making related to Manitoba's land and water resources, and likely the *Technical Review Committee* process itself – for the benefit of all stakeholders affected by the hog industry.

Several proposed recommendations for addressing these issues and opportunities are contained within the *Summary Conclusions and Recommendations* of this report (Section 4), encompassing our findings and learnings from both Task 1 and Task 2 of this research.

3.3 Exploring the Technical Review Committee Process

Individual meetings were conducted with organizations associated with the Technical Review Committee process, including Manitoba Agriculture, Food and Rural Initiatives, Manitoba Water Stewardship, Manitoba Conservation, and Manitoba Intergovernmental Affairs, several municipal representatives, the Clean Environment Commission, the Manitoba Pork Council, The Manitoba Eco Network Water Caucus, the Manitoba Conservation Districts Association, the Farm Stewardship Association of Manitoba, and two private consultants.

The focus of each meeting was the TRC process for the hog industry, but latitude was given to ensure the individuals were able to raise and discuss hog industry concerns not necessarily associated with the TRC. Numerous issues were raised about the current process for expansion within the hog industry as well as a few suggestions for improved production practices.

The issues discussed have been grouped into four key areas: policy issues, resource issues, TRC process and manure management. Some of the issues were cross cutting over these key areas, and will be outlined in the most appropriate section but mentioned in all relevant areas.

3.3.1 Policy Issues

Policy Issues were identified by most of the individuals involved in the meetings. The issues extended across provincial policies and rural municipalities. The following is a brief description of the issue.

- Provincial departmental silos
- Current policies and regulations not effectively managing water issues
- Merging of planning and conservation districts
- Vague relationship between TRC and Planning Act
- Conditional Use Hearing Triggers
- Training of RM staff
- Odour issues
- Impacts of “Pause”

Several individuals mentioned that many of the provincial departments are focusing on their mandates without recognizing some of the linkages and impacts of their activities and the mandate of other departments. It was pointed out that MAFRI promotes the expansion of the hog industry since it is a significant contributor to economic growth, which it is, but has not allocated the resources to ensure it does not interfere with the Water Stewardship’s mandate to promote health water resources in Manitoba. Some of the participants suggested that there needs to be better communication between provincial departments and strategies developed so they can work more effectively together.

The Technical Review Committee is a good example of the departments working together to provide background information to RMs about proposed livestock operations. Some participants pointed out though that some departments take these reports more serious than others. Manitoba Conservation provides very basic information in the TRC report, but does get into more detailed analysis for the permitting portion of the livestock operation application.

Manitoba's water resources are impacted by its economic, social and environmental policies. Many of the policies are designed to address a particular policy area and impacts in other sectors are unintentional. Some policies have specific water goals in mind, but lack the resources to fulfill their objectives. None of the review processes examine the potential cumulative effects of adding more livestock operations to a region or watershed. The current restrictions are based on number of animals per barn. Some proponents have circumvented the process by establish more barns but under the 300 AU limit. This effectively increases the number of animal units in an area without the hassles of a conditional use hearing. The impact of more animal units in a given area increases the potential risk to the water resources.

Concerns were raised about the number of organizations were been formed that were similar in nature to some extent and the possibility to combine their functions. The Planning Districts and the Conservation Districts were identified as another layer of quasi-government operating in a region when the Provincial government is trying to cut costs. Although there are differences between the two groups, there was a consensus that these groups need to work closely together to establish realistic agriculture and in particular livestock zones.

The Planning Act was discussed by several of the interviewees, with most considering the Planning Act too ambiguous by not being more definite in the role of the TRC and how the planning districts would work with other groups, such as the conservation districts as well as rural municipalities. It was also mentioned that the Planning Act requires each municipality to have established agricultural zone for livestock operations. The RMs have until January 2008 to have determined their agriculture zones. Many RMs have put this on hold until the results of the pause are known.

The number of animal units in a barn determines whether or not a conditional use hearing or TRC process is required. Concerns were raised that some operations use multiple barns of less than 300 AU to avoid the hassles of conditional use hearings and other regulations. Some participants felt the current number of 300 AU is appropriate, but there is a need to ensure multiple barns and other techniques to avoid regulations are not allowed. In Quebec, for example this is no lower limit. All operations are reviewed.

Concerns were that in some of the RMs did not have the resources or staff equipped to handle the livestock activities. Some of the RMs have been conducting conditional use hearings on a regular basis, while others are new and are having significant issues. Examples were given of RM Councilors requiring police escorts and having threats made against them. Better training of RM staff was suggested as one method to avoid some of these conflicts. Record keeping was an area of concern that better training might improve.

Currently odour is the responsibility of the RM, and concerns were raised that not all of the RMs addressed the issue adequately. During the conditional use hearings, RMs have the opportunity to establish rules for the livestock operation in terms of odour management. These rules could include covers over manure storage and the use of shelter belts to reduce odour due to wind. After the hearings, and establishment of the facility however, any odour complaints are required to be sent to the Farm Practices Review Board. The FPRB determines if the farm is operating responsibly and using accepted farm practices.

Currently a temporary ban on the establishment of any new barns for hog production purposes exists. The “Pause” has resulted in a number of policy related impacts, such as agriculture zones in RMs. The Planning Act requires that RMs develop a livestock by-law, but many have discontinued the development of their by-laws because of the additional expenses. The RM’s do not want to invest in these by-laws until the results of the pause are known. Another concern raised was the potential for a large rush on the TRC process from farmers waiting for the Pause to end. It was estimated that for new barns to be ready for 2009, the Pause would need to be lifted by the end of November. The Pause does not impact existing operations.

3.3.2 Resource Issues

A variety of resource issues were identified has significant problems. Like the policy issues the resource concerns were wide ranging including provincial and municipal governments and farmers.

- Quality of data (regulations based on questionable science)
- Manure data problems and gaps
- Lack of resources for proper assessments and follow-up
- Enforcement and monitoring
- Farmers ability to make changes

Questions were raised about the quality of the data used to develop policies and regulations for water resources and manure management, in particular the nutrient loading in Manitoba watersheds. The study being used now is preliminary data that was developed using coefficients not ideal for the general Manitoba landscape. Comments were received from some of the participants that the nutrient loading estimates could be as much as 40% out. It was suspected that agriculture was under-estimated while the natural lands were over-estimated.

The Manitoba hog population is difficult to determine because small operations have incentive not to share this information due to contract negotiations with the processors. The Manitoba Pork Council does not have precise information of the number of hogs, even though their funding comes from a check off program. Statistics Canada has the best estimates of hogs on Manitoba farms.

The identification of spread fields and the annual amount being applied to the fields was identified as a major concern by a variety of the participants. While efforts are being made to collect the data and improve the information being made available, significant problems exist in tracking the information and having it available for the TRC and subsequent conditional use hearings. Manure management plans are required on an annual basis from each farm over 300 animal units. Farms below the 300 AU are not filing these manure management plans. There is a potential for some fields to be receiving excess quantities of manure.

Nitrogen has been the main focus of the data collected until very recently, so with the addition of phosphorus to the manure limits, the area of spread fields required has increased significantly for proposed new developments and existing livestock operations. The manure management plans require that the farmer submits soil sample from the spread fields before and after manure application. 10% of these samples are audited to ensure compliances with the regulations. 80% of the audit samples were within the regulation limits. Phosphorus testing will now be included in the auditing process. Concerns were raised that this information was not being used by the TRC process to ensure proponents were not using the same fields.

The amount of information provided for the TRC report and conditional lands use hearings with respect to location and possible impacts on watersheds was called into question by several organizations. It was recognized that proponents are reluctant to pay for expensive soil and water sampling at the early stages of the review since the RM has the ability to say no without any opportunity for appeal. Some suggested that large operations should be responsible for these costs and have the analysis completed for the conditional use hearings, and that smaller family operations could have this expense back stop by some form of government fund if their application was denied before the permitting process.

Enforcement and monitoring was raised as very significant issues with several severe examples from the late 1990s. Although these examples are not indicative of the current situation, the ability to enforce the current regulations is not sufficient. It was suggested that if all federal, provincial and municipal regulations were followed, Manitoba's water resources would not be threatened. Monitoring and enforcement resources were seen as very limited. One RM pointed out that Hog Watch was responsible for the initiation of several investigations and not their own monitoring system.

Another resource issue raised was that many farmers are in difficult financial situations, and can not afford to adopt new technologies to manage nutrients outflows. Beneficial management practices are available to address manure management, but still require significant funds from the farmer. Not all farmers are taking advantage of some of the programs available to them to improve their environmental impacts.

3.3.3 Technical Review Committee

The Technical Review Committee was the subject of most of the discussions, and as a result several issues and suggestions were discussed. The issues discussed are highlighted below:

- Purpose of the TRC
- Membership of the TRC
- Utility of the TRC report
- Public input into TRC process and RM decision
- Environmental assessment v.s. conditional use hearing

Several participants in the discussions were concerned about the purpose of the TRC, many felt the TRC needed to provide much greater detail to improve the RM's ability to make informed decisions. Most recognized that the TRC was initially established to provide background information to the RM council before making decisions about livestock operations. Some participants complained that the TRC reduced the ability of non-members from the provincial government to provide relevant input into the conditional use hearings and the reports. The most common complaint was the lack of detailed information being made available to the RMs.

Membership of the TRC was also discussed in detail, particularly around the idea of more local knowledge. Potential additional members included a representative from the RM, such as the CAO, a representative from the local conservation district, as well as other provincial departments (highways) or federal departments (PFRA). It was recognized that making the membership of the TRC too large would significantly reduce the efficiency. One suggestion was to have the TRC members actively solicit comments from external sources, such as the potential membership listed. The purpose of expanding the membership of the TRC was to inject more local knowledge and other areas of potential conflict.

The utility of the TRC report was questioned by several of the participants as they felt more information should be made available in a timely fashion. Some departments used standard boiler plate information in each report, which was not specific to the potential barn location, while others only address a portion of the issue. The permitting process that follows the conditional use hearing, where the TRC is discussed, provides much more information about the water resources in the area.

Public input into the TRC process and conditional use hearings was a contentious issue as some felt it was acceptable and others thought it was too little. The argument for more public participation focused on some RMs were livestock friendly and were allowing operations that were detrimental to other citizens in the RM. Concerns were on water resources, odours, property values etc. It was also suggested with more detailed information from the TRC process would reduce some of the concerns local citizens had about the proposed livestock operations. Concerns were also raised about participants in the conditional use hearings coming from a variety of regions not just the local RM.

To ensure a more complete evaluation of proposed livestock operations some participants have suggested removing the TRC process and replacing it with an environmental assessment. The argument for an environmental assessment is based on more detailed analysis as well as more public input into the process. Concerns are that it would be time consuming and more resources would be expended to review a livestock operation. Most RMs are opposed to an environmental assessment since control of the process would be with the provincial government, not allowing the RMs to decide if they want livestock operations or not.

3.3.4 Manure Management

The major reason for the focus on the hog industry has been around manure management and its impacts on water resources. Although current estimates are that hog production is a small contributor of nutrients to Lake Winnipeg and its watersheds, the risk for higher nutrient loading increases with more hog barns. Tracking locations of potential nutrient hazards was seen as a priority. Several participants raised a number of suggestions to reduce the amount of nutrients released from the hog operations.

- Manure database
- Whole farm nutrient balance
- Better feeding rations for hogs
- Improved manure handling techniques

The current manure database constructed and maintained by Manitoba Conservation is not link to water resources. The database is currently linkable to soil types. Suggestions where made to expand the capacity of the manure database to be able to monitor potential nutrient loading within watersheds. Ideally the database would also be able to track barns below the 300 AU if they are in potential high nutrient loading areas.

The concept of whole farm nutrient balance was introduced by several individuals. Farmers are required to measure the amount of nutrients entering the farm and the nutrients leaving the farm. This approach reduces some of the immediate concerns of being able to track the nutrients in watersheds. Quebec and other jurisdictions have experimented with this technique and it appears to be successful. Efforts are currently underway with Manitoba Conservation to improve some of the nutrient loads from hogs using a whole farm nutrient balance.

Applying a similar technique by measuring the nutrients in hog rations to the nutrients out in the form of meat and manure provides some bases to reduce nutrient levels in the manure. In Quebec, significant reductions in manure nutrients were noticed by changing the feed rations for the animal. Although research is being conducted in this area, results have been dependent on the type of feed available. The current grains supplies are designed for human markets and not livestock, but new grains are being developed for hogs that will reduce nutrient levels in the manure.

New and old technologies exist that improve the portability of manure. Many of Manitoba's agricultural landscapes are nutrient deficient and would benefit from the addition of manure. Unfortunately, the transporting of manure distances beyond 5-10 kilometres becomes expensive. In areas of high livestock concentrations the application of manure has increased the nitrogen and phosphorus levels in the soil beyond the ability of the crops to absorb the nutrients. In the past nitrogen levels were used to determine acceptable rates of manure application. New phosphorus regulations now require phosphorus to be measured as well.

Phosphorus is considered a greater concern because the ratio of phosphorus to nitrogen is considerably higher in manure than what the crop requirements are. As a result manure applied at acceptable rates for nitrogen results in an oversupply of phosphorus, which increases the potential for phosphorus loading in the watershed. By using phosphorus as the new limits significantly more acreage of spread fields are required.

3.3.5 Synthesized TRC Findings from Meetings:

The following general recommendations were synthesized from these meetings:

- Ensure better interaction between provincial departments
- Clarify the policies associated with the hog barn proposals
 - Define the role of the TRC better in the Planning Act
 - Indicate how Planning districts and Conservation districts interact
- Enforce and tighten regulations associated with water resources
- Improve quality of water resource data
 - Consider cumulative impacts
 - Nutrient loading within watersheds
- Increase resources for assessments and monitoring
 - Expand the manure database to include risk to water resources
 - Share database in aggregate form
 - Provide site inspections
 - Improve training for RM staff to manage livestock proposals
- Clarify purpose of TRC and role at conditional use hearings
- Review membership of TRC
 - Improve local knowledge content
 - Involve other departments where appropriate
- Improve public participant at conditional use hearings
- Provide more site specific detail in TRC report
- Improve manure management
 - Introduce whole farm nutrient balance
 - Reduce nutrient levels in manure
 - Condense manure for easier transport

Overall Issue	Key Issue
Policy	Provincial departmental silos
	Current policies and regulations not effectively managing water issues
	Merging of planning and conservation districts
	Vague relationship between TRC and Planning Act
	Conditional Use Hearing Triggers
	Training of RM staff
	Odour issues
	Impacts of “Pause”
Resource Issues	Quality of data (regulations based on questionable science)
	Manure data problems and gaps
	Lack of resources for proper assessments and follow-up
	Enforcement and monitoring
	Farmers ability to make changes
Technical Review Committee	Purpose of the TRC
	Membership of the TRC
	Utility of the TRC report
	Public input into TRC process and RM decision
	Environmental assessment v.s. conditional use hearing
Manure management	Manure database
	Whole farm nutrient balance
	Better feeding rations for hogs
	Improved manure handling techniques

4 Summary Conclusions and Recommendations

Provincial Strategic, Policy, and Scientific Concerns

1. Given that watershed processes largely dominate the contribution of nutrient loads to Lake Winnipeg, and if phosphorus reduction is truly an overriding objective for the Province of Manitoba, **provincial efforts in support of Integrated Watershed Management (IWM) or Integrated Water Resources Management (IWRM) must be dramatically increased.** Furthermore, the Intergovernmental Panel on Climate Change Fourth Assessment Report (2007) also recommends IWRM as a key strategy for reducing climate change vulnerability – including the shock nutrient loads associated with the extreme precipitation events that are projected for the Canadian Prairies.
2. Essentially, the next stage of the *Manitoba Water Strategy* and implementation of the *Water Protection Act* logically involves significantly strengthening Manitoba Water Stewardship to actually implement “watershed-based decision-making.” Manitoba Water Stewardship was originally conceived as an apex, coordinating department – exactly the role which now must be strengthened to achieve comprehensive nutrient management based on a *Total Nutrient Loading Framework*. **Internal recognition of the *Manitoba Water Strategy* as a *Key Cross-Government Strategy*, based on similar efforts already in place in both Alberta and Saskatchewan – where all participating departments are jointly accountable for strategy results – is also essential.** This would require full Executive Council support to be adopted as “province-wide” in its scope and importance – therefore harnessing the full attention, resources, and credibility of the Manitoba government. **One of the prime indicators for the success of the *Manitoba Key Cross-Government Strategy for Water* should be Total Phosphorus Reduction (TPR).** Appropriate performance measurement would also require a watershed-based reporting framework similar to the Saskatchewan State of the Watershed Reporting System, which tracks a suite of science-based indicators within every watershed in the province. These indicators are used to assess the current health of Saskatchewan’s watersheds, provide information about human activities that impact the environment within watersheds, and evaluate the effectiveness of various planning and management activities occurring within them. The indicators include “condition” indicators, “stressor” indicators, and “response” indicators. **Development of Manitoba’s State of the Watershed Reporting System must begin as soon as possible – coordinated by Manitoba Water Stewardship, but also involving all other applicable departments.**

3. The Manitoba Water Strategy and the Water Protection Act are fundamentally consistent with the principles of sound land and water management based on watersheds, as well as a watershed-based framework for the reduction of nutrient loading. It is now time to begin making the difficult governance and jurisdictional accountability choices which are required to actually implement IWRM and TPR. **Meaningful progress on The *Manitoba Key Cross-Government Strategy for Water* would by definition require a high degree of formalized interdepartmental planning and cooperation involving all departments with applicable roles in achieving strategy progress.** There is currently a significant lack of formal Manitoba Government interdepartmental cooperation occurring currently in the area of natural resources management and development. However, opportunities do exist to coordinate this function through the Community and Economic Development Committee of Cabinet, the former Sustainable Development Committee of Cabinet, the Manitoba Round Table on Environment and Economy (if it includes Cabinet participation), the Interdepartmental Planning Board of Deputy Ministers, the Conservation Districts Commission of Deputy Ministers, and possibly the Lake Winnipeg Stewardship Board. Based on the following recommendations however, it is proposed that **the current Conservation Districts Commission should be renamed with increased responsibilities for ensuring clear program direction and evaluation, performance measurement, and interdepartmental planning, cooperation, and support as the *Watershed Authorities Commission – reporting to the Minister of Water Stewardship*.** This proposal is consistent with current government policy on water, as well as the original intent of the *Manitoba Water Strategy* and the *Water Protection Act*.
4. In order to properly assess the incremental phosphorus contributions of new individual hog development proposals, **a better scientific understanding of Manitoba's proportion of *Total Phosphorus Loading* is fundamentally required.** There are multiple sources of these loads beyond hog manure, particularly regarding the interrelated components of *Manitoba Watershed Processes* and particularly within the Red River Basin, where the majority of these loads appear to be generated. Focused and comprehensive research into these sources is required at several nested watershed scales – at specifically the individual hydrologic unit, the minor watershed, subwatershed, and watershed levels – towards the generation of long-term Manitoba data which will contribute to a clarified understanding regarding watershed process –based nutrient loading, including agricultural contributions, as well as the impacts of beneficial management practices (BMPs). **The only location where logical where relevant watershed science research is occurring in Manitoba is in the Tobacco Creek Watershed, where Manitoba's only long-term dataset regarding agricultural impacts on water quality and quantity is based.** This research has taken place for two decades mostly through community initiative and without long-term funding commitments from government at any level. **The Province of Manitoba should significantly increase its participation in this research – and through the proposed *Watershed Authorities Commission* and the proposed *Manitoba Watershed Science Center* (see below), initiate comparable research in other Manitoba watersheds.**

5. Strengthening the watershed science capacity generally within the province will require long-term commitments by the Manitoba Government toward building professional expertise focused on all aspects of watershed management. The Watershed Science Centre at Trent University in Peterborough, Ontario is an important model for government-academic partnership that could be emulated in Manitoba – in cooperation with this province’s universities. **The important role of social science in supporting the fundamental governance and community participation elements of IWRM should be included as part of the general strengthening of watershed science in the province, including that undertaken by a *Manitoba Watershed Science Centre*.** Manitoba Water Stewardship should ultimately become the repository or central access point for all provincial data applicable to the province’s watersheds – to be utilized by Manitoba’s Local *Watershed Authorities* in their exploration and consideration of watershed issues (see below).

Local Watershed Authorities for Planning, Monitoring, and Management

6. There is a great need to improve the means by which new hog developments are reviewed and approved. While inherently local in nature, these decisions must be considered within the broader context of Total Nutrient Loading (or Total Phosphorus Loading to start). While Lake Winnipeg has been identified as an iconic feature and focus to address growing public concerns regarding water quality in Manitoba and significant nutrient loads to Lake Winnipeg do come from beyond Manitoba’s borders, it is important to note that fully 47% of phosphorus loads and 49% of nitrogen loads are generated within Manitoba. In terms of phosphorus alone, *Manitoba Watershed Processes* are estimated to be equal in scale to US sources (at 32% of Total Phosphorus Loads), with this total almost evenly comprised of “natural background/undefined” and “present day agriculture” and the vast majority of this generated within the Red River Basin, both in Manitoba and the US (54% overall). **These watershed processes (and their subsequent nutrient loads) are fundamentally hydrologic in nature. As such, there is a need for greater scientific, technical, and decision-making capacity regarding the interrelated elements of both agricultural land use and the flow of water within local watersheds (including their individual hydrologic units, minor watersheds, and subwatershed systems).**

7. While appearing as logical existing entities to assume greater responsibility for local watershed planning and decision-making, Manitoba's Conservation Districts will have difficulty fulfilling this role until they can develop greater professional capacity to provide accurate scientific and technical information regarding all aspects of the watersheds they should be responsible for. **There is a need to integrate the emergent watershed planning functions of conservation districts with the existing land use planning functions of planning districts – for the benefit and use of their member municipalities. Doing so would provide the opportunity for a comprehensive, watershed-based planning, management, and monitoring framework – through which the potential impacts (i.e. phosphorus loading) arising from an incremental increase in hog manure (or other forms of development) could be appropriately considered in the broader context of *Total Land and Water Management*.**

Manitoba's Conservation Districts should now be given greater responsibility (with appropriate resources) for planning and managing the rural watershed landscapes that serve as the contributing drainage systems for their local watersheds, including nutrient budgets. In February 2007 the Minister of Water Stewardship declared essentially this intention, indicating that the Lake Winnipeg Stewardship Board would be responsible for coordinating nutrient management plans through the Conservation District Program.

8. For the most part, CDs are not watershed-based, nor do they currently have the capacity or capability to significantly influence the individual management/development decisions of landowners or the planning decisions of their rural municipal members. Equally, they currently lack the technical capacity or mandate to conduct regular scientific monitoring or provide regular reporting on the health of their local watersheds. It is recognized that some CDs are now attempting to plan and manage some watersheds sustainably under the auspices of the Manitoba Water Protection Act. It is also recognized that the provincial conservation districts program has a stated desire to move toward watershed boundaries. While Manitoba's CDs are now being expected to play a central role in addressing the challenge of declining water quality in Lake Winnipeg, this challenge was not foreseen as a CD responsibility during initial program design. At this point, Manitoba's CDs are not adequately prepared to address this capacity gap. **The Province of Manitoba can now appropriately address this challenge within the framework of existing legislation, strategies, and programming (see detailed recommendations below).**

9. In addition to their partner municipalities, Manitoba's Planning Districts can and do have a large measure of influence over the individual management/development decisions of landowners – as they also do among their partner municipalities – during the development planning process mandated through the Planning Act. Some municipalities are not members of Planning Districts and thus must prepare their development plans on their own, which can also be problematic with regard to environmental concerns, such as those related to the flow of water, which are almost always transboundary in nature. However, **given that agricultural and other nutrient loading sources are fundamentally hydrologic in nature, it would be most appropriate if an authority responsible for watersheds were also responsible for the agricultural and land use aspects of rural land use zoning.** These activities and responsibilities must be done within the context of watershed planning and management. As such, **this function should now be transferred from Manitoba's Planning Districts to local authorities responsible for local watersheds (see below).** This requires the legislative movement of these aspects of the *Planning Act* to the *Water Protection Act*, including current planning considerations for at least three relevant Provincial Land Use Policies (Policy 2-Agriculture, Policy 4-Water and Shoreland, and Policy –Flooding and Erosion) as well as provisions for the municipal consideration of new livestock developments as well as the *Technical Review Process*.
10. **Total nutrient loads are a function of hydrologic flow (through watershed processes). If the concern is *Total Nutrient Loading* in these agricultural zones, these land and water planning features/functions must be integrated. As such, agricultural zoning must be done in the context of watershed planning and management.** A long-term vision which may someday see the amalgamation of Manitoba's Rural Municipalities along watershed boundaries – is entirely consistent with the long-term goal of ecosystem-oriented governance as essential to sustainable development – and is probably inevitable in the future. However, what is required now is the creation of Local *Watershed Authorities* which are responsible for the interrelated aspects of land use and water flow as it relates to *Total Land and Water Management*, watershed health, watershed integrity, source water protection, biodiversity, drainage, and nutrient loading. These *Watershed Authorities* can and should easily be established using legislation, strategies, and programs which currently exist. **Manitoba's Conservation Districts should now be reconstituted along watershed and/or subwatershed boundaries and renamed at *Watershed Authorities* (at whatever the most *meaningful and manageable* unit is – depending and focused upon particular communities/municipalities in specific locations of Manitoba).** Most existing activities and operations outlined within the *Manitoba Conservation Districts Act* should be transferred to the *Water Protection Act*, which outlines the source water protection responsibilities of “local water planning authorities,” which should logically and simply now be called *Watershed Authorities* in the *Water Protection Act*. The *Manitoba Conservation Districts Act* could and should then be repealed as a consequential amendment. **This should be considered as the logical first step in the “review and consolidation of water legislation” which was identified as a critical element initially envisioned and clearly articulated within the Manitoba Water Strategy in 2003.**

Improving Hog Industry Development Decision-Making Towards Phosphorus Loading Reduction

11. There are significant concerns among many stakeholders regarding the current *Technical Review Committee* process for reviewing new hog industry development or expansion proposals. For many reasons, it has become clear that this process is not meeting the needs of all industry proponents, the public living within municipalities considering these developments, or the Rural Municipalities themselves. There is a need for more comprehensive technical information regarding each application, and this information must be considered and presented within the hydrologic context of watersheds and *Total Nutrient Loading* of these watersheds. As such, it is abundantly clear that **Manitoba's proposed new and appropriately resourced *Watershed Authorities* should now become responsible for coordinating the Technical Review Committee process – through the collection of provincial data and its synthesis focused on the local watershed they are responsible for.** This focused process would see Manitoba's new *Watershed Authorities* serving as an accurate source of useful information prior to a Rural Municipality's consideration of a new hog industry development proposal. **A *Watershed Authority* should be able to report effectively on the incremental *Total Nutrient Loading* impact of one additional hog development – by assembling all required data from all applicable provincial government departments – and presenting it in an understandable format which proactively addresses the needs and potential concerns of the municipality, community residents, and the development proponent (who will be able to better plan their proposed operations from the beginning).** Participating provincial departments providing this information would all logically be members of the *Watershed Authorities Commission* chaired by Manitoba Water Stewardship.

12. While the new local *Watershed Authorities* would be responsible for much of the analysis, modeling, and professional technical research required for the effective preparation of a *Technical Review Committee* report based on the coordinated input of applicable provincial departments, Manitoba Conservation would retain its current regulatory roles regarding manure storage and spreading under the *Environment Act's Manure Management and Livestock Mortalities Regulation*. However, **the 300 animal unit threshold should be eliminated for the requirement of a manure management plan, as well as the numerical trigger for the *Technical Review Process*.** All hog producers should be required to have a manure management plan based on the phosphorus saturation limits of their soils, and all new or expanded hog industry developments/barns should undergo a TRC process coordinated by the Local *Watershed Authority* on behalf of their member municipalities. **The TRC process would become dramatically more efficient and cost-effective than it is now. After initially collecting and synthesizing the required data for its local watershed, a *Watershed Authority* would simply have to update its *Total Nutrient Loading database* to reflect the subsequent incremental changes of new, expanded, or reduced hog industry developments (in addition to monitoring other nutrient sources).** The TRC would then be in a better position to provide useful information regarding other aspects of livestock industry development within agricultural watersheds/communities.

13. Data collection related to the identification and monitoring of spreadfields and the annual amount of manure being applied to these fields is a significant concern. **While efforts are being made by Manitoba Conservation to collect the data and improve the information being made available, significant problems exist in tracking the information. This data is incomplete, but represents very much of the foundation of that which would be required for the incremental assessment of hog industry expansion through the development of new hog barns.** It would also be useful to the TRC and/or for consideration at subsequent conditional use hearings. Similarly, manure management plans are required on an annual basis from each farm over 300 animal units, but farms below the 300 AU are not required to file these manure management plans. As such, it is quite likely that some fields are receiving excess quantities of manure. There is a need for a comprehensive spatial database to manage and maintain this data. The fact that this system is not already in place is a fundamental handicap. **The accurate collection of this data requires the immediate and long-term cooperation of Manitoba's cattle and hog producers (represented by their member organizations) and all applicable government departments (primarily MAFRI and Manitoba Conservation – working closely with Manitoba Water Stewardship. This level of industry-government cooperation occurs in Québec) and should be emulated in Manitoba.**

5 References

Allee, D.

1987 A Critical Review of the River Basin as a Focus for Resources Planning, Development, and Management, *In* Baumann, D. and Y. Haimes, eds. *The Role of Social and Behavioural Sciences in Water Resources Planning and Management*. New York: American Society of Civil Engineers, New York, p. 294-312.

Deerwood Soil and Water Management Association

2003 South Tobacco Creek Project. Electronic Document, <http://www.deerwood.mb.ca/stc01.html>, accessed 25 July 07.

FT-Ecologistics Ltd.

1998 Manitoba Conservation Districts Mandate Study. Winnipeg: Manitoba Rural Development.

Galloway, G.

1988 The Role of Social Sciences in Putting “People” into Federal Water Resources Project Planning and Evaluation. *In* Baumann, D. and Y. Haimes (eds) *The Role of Social and Behavioural Sciences in Water Resources Planning and Management*. New York: American Society of Civil Engineers, New York, p. 313-325.

Heindl, L.A.

1972 Watersheds in Transition: Quo Vadis? *In* Csallany, S. et al eds. *Proceedings of a Symposium on Watersheds in Transition*. American Water Resources Association, Fort Collins, CO.

IISD (International Institute for Sustainable Development) and TERI (The Energy and Resources Institute)

2003 A Framework for Energy Sustainability Assessment: The Energy Sustainability Gauge. Winnipeg and New Delhi: IISD and TERI. Electronic Document, http://www.teriin.org/ee/gbr/fesa/fesa_report.htm, accessed 20 June 2007.

Jønych-Clausen, Torkil

2004 Integrated Water Resources Management (IWRM) and Water Efficiency Plans by 2005 - Why, what and how?” Global Water Partnership, Technical Committee.

Krenz, Gene and Jay Leitch

1993 A River Runs North. Fargo, North Dakota: Red River Water Resources Council.

Lake Winnipeg Stewardship Board

2007 About Lake Winnipeg Stewardship Board. Electronic Document, <http://www.lakewinnipeg.org/web/index.shtml>, accessed 25 Aug 07.

Lake Winnipeg Stewardship Board

2006 Reducing Nutrient Loading to Lake Winnipeg – Our Collective Responsibility and Commitment to Action: Final Report to the Minister. Winnipeg: Manitoba Water Stewardship, Lake Winnipeg Stewardship Board.

Lower Souris River Watershed

2007 LSRW Services. Electronic Document, <http://www.lowersourisriverwatershed.com/services.html>, accessed 22 February 2007.

- Manitoba Conservation
2003 The Manitoba Water Strategy. Winnipeg, MB.
- Manitoba Conservation
2002 Manitoba Water Quality Standards, Objectives, and Guidelines: Final Draft for Review and Comment. Electronic Document,
http://www.gov.mb.ca/waterstewardship/water_quality/quality/website_notice_mwqsog_2002.html
- Manitoba Conservation
2001 Building a Sustainable Future – Water: A Proposed Strategic Plan for Manitoba. Winnipeg, MB.
- Manitoba Environment and Workplace Safety and Health
1988 Guide to the Manitoba Environment Act. Winnipeg, MB. 29p.
- Manitoba Government
2007 News Release: Lake Winnipeg Stewardship Board Receives Expanded Mandate: Melnick: 14 February. Electronic Document,
<http://www.lakewinnipeg.org/web/content.shtml?pfl=public/downloads.param&page=000101&op9.rf1=000101>, accessed 15 June 2007.
- Manitoba Government Queen's Printer
1987 The Public Health Act: RSM 1987 c. P210 and CCSM 1987 c.P210. Available:
<http://web2.gov.mb.ca/laws/statutes/ccsm/p210e.php>
- Manitoba Government Queen's Printer
2006 The Public Health Act: SM 2006 c. 14. Available:
<http://web2.gov.mb.ca/laws/statutes/2006/c01406e.php>
- Manitoba Government Queen's Printer
2002 The Drinking Water Safety Act: SM 2002 c. 36 and CSSM c. D101. Available:
<http://web2.gov.mb.ca/laws/statutes/ccsm/d101e.php>
- Manitoba Government, Queen's Printer
1987-88 The Environment Act: SM 1987-88 c. 26 and CSSM c. E125. Available:
<http://web2.gov.mb.ca/laws/statutes/ccsm/e125e.php>
- Manitoba Intergovernmental Affairs
2007 Planning for Livestock. Presentation to the Manitoba Clean Environment Commission, Winnipeg, Feb 07.
- Manitoba Statutes
2007 The Water Protection Act: C.C.S.M. c. W65. Electronic Document,
<http://web2.gov.mb.ca/laws/statutes/ccsm/w065e.php>, accessed 20 Aug 07.
- Manitoba Statutes.
2007b The Conservation Districts Act: C.C.S.M. c. C175,. Electronic Document,
<http://web2.gov.mb.ca/laws/statutes/ccsm/c175e.php>, Accessed 15 July 2007. Also: The Watershed Conservation Districts Act, Chapter 70, 1959, and The Resource Conservation Districts Act, Chapter 54, 1970, available: Manitoba Legislative Library.

Manitoba Statutes

2005 The Planning Act: CCSM c. P80, Electronic Document,
<http://web2.gov.mb.ca/laws/statutes/ccsm/p080e.php>, accessed 10 Sep 07.

Manitoba Statutes

1998 The Livestock Manure and Mortalities Management Regulation: 42/98 with Subsequent Amendments (52/04, 194/05, and 219/06). Electronic Document,
<http://web2.gov.mb.ca/laws/regs/pdf/e125-042.98.pdf>, Accessed 25 Aug 07.

Manitoba Statutes

1994 The Provincial Land Use Policies Regulation: 184/94 with Subsequent Amendment (249/06).
Electronic Document, <http://web2.gov.mb.ca/laws/regs/pdf/p080-184.94.pdf>, accessed 20 Sep.

Manitoba Water Stewardship

2007 The Manitoba Water Strategy. Electronic Document,
<http://www.gov.mb.ca/waterstewardship/waterstrategy/index.html>, accessed 30 Aug 07.

Ogrodnik, L.

1984 A History and Policy Review of water Management in the Lower Red River Basin. Winnipeg:
Natural Resources Institute, University of Manitoba.

Province of Manitoba

2006 Terms of Reference: Regional Technical Review Committee Process for Livestock Operations.
Winnipeg: Province of Manitoba.

Red River Basin Commission

2005 Natural Resources Framework Plan. Available: <http://www.redriverbasincommission.org/>,
accessed 15 July 2007).

Saskatchewan Finance

2007 Public Accounts for 2006-07, <http://www.publications.gov.sk.ca/details.cfm?p=23453>

Saskatchewan Watershed Authority

2007 State of the Watershed Report. Available:
<http://www.swa.ca/StateOfTheWatershed/Default.asp>, accessed 15 September 2007.

Saskatchewan Watershed Authority

2003 A Watershed and Aquifer Planning Model for Saskatchewan. Moose Jaw, 12 p.

Simpson, J.

2004. The Drinking Water Safety Act, *Underneath the Golden Boy*, Vol. 3, p. 1-2.

Swanson, Darren, Stephan Barg, Henry Venema, and Bryan Osborne

2005 Prairie Water Strategies: Innovations and Challenges in Strategic and Coordinated Action at the
Provincial Level. Electronic Document, http://www.iisd.org/natres/water/pwps_background.asp,
accessed 2 March 2007.

Tobacco Creek Model Watershed

2004 People, Landscape, Planning, Action: Water Strategy Blueprint: Roland, MB, TCMW, Watershed
Management and Research Plan. Electronic Document,
<http://www.tobaccocreek.com/proposal.php>, accessed 25 July 2007.

Turtle Mountain Conservation District

2004 Taking Care of Our Watershed: A Watershed Plan for the East Souris River Watershed, Manitoba, Canada. Deloraine, Manitoba, ESR Watershed Planning Advisory Team. Electronic Document, http://www.tmcd.ca/watershed/watershed_management_plan.html, accessed 24 Jul 07.

Vaisey, J.S.

1979. Water Quality Policy in Manitoba: History, Administration, Implementation. Natural Resources Institute, University of Manitoba, 147 p.

White, G.F.

1957 A Perspective of River Basin Development," Law and Contemporary Problems, 22(2):157-184. (In English and Japanese.). Also see: <http://www.colorado.edu/hazards/gfw/>