An Analysis of Agricultural Land Use and Management in the Pembina River Watershed

Submitted by

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and

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A. Executive Summary

Understanding changes in agricultural land use is essential for the development of the integrated watershed management plan. Examination at a subwatershed scale provides a snapshot in time of the agricultural footprint on the in the Pembina River Watershed. Census of Agriculture data, temporal in nature, illustrates influences from external factors like weather, government programs and polices, market drivers, and technology to land management decisions and the community response to those interactions. Such events, with an examination of a watershed's physical resource characteristics and risks, assist to develop an understanding of potential impacts on the basin's water quality, and identify opportunities for future sustainable land use strategies. This is particularly important to the Pembina River Integrated Watershed Management Plan where, through public consultation, five key issues emerged: Flooding, Drinking Water Quality, Surface Water Quality, Soil Erosion, and Drainage. For the purpose of this document, the issues of Flooding and Drainage were viewed as interconnected and grouped into one category called Surface Water Quantity. The overall objective of this document is to examine risks to key watershed resources by analyzing the physical characteristics of the landscape with consideration for how specific agricultural activities may be affecting them, both positively and negatively. This analysis will then serve as the basis for recommended action items to address the identified risks.

The Pembina River Watershed study area is located in south central Manitoba, and consists of only the Canadian portion of the Pembina River Watershed (approximately 488,257 ha in size). Ag-Profiling examined variables from 2006 Census of Agriculture database depicted over four subwatershed regions, including farm area, type of farm, cropping practices, tillage practices, herbicide/pesticide use, type of fertilizer application, financial activity, and average herd size. From a time period of 1971 to 2006, the same variables from Census of Agriculture data were used to analyze trends. Land cover data from 1994, 2001, and 2006, based on LANDSAT Thematic Mapper satellite imagery, were used to examine temporal changes in land cover. Using soils data and modeling, environmental indicators were developed for Agricultural Capability, Wind and Water Erosion Risks, and Soil Drainage characteristics. These were examined in combination with the annual cropland identified in the 2006 and 2000 land cover mapping. A review of recent federal and provincial policies and programs was conducted to assess their impact on agricultural land use and management.

Results showed the Pembina River watershed as a vibrant and diverse agricultural landscape. Slight differences were evident from the eastern portion of the watershed compared to the west with respect to cropping practices, crop types, types and number of livestock, and poultry. Farms in the western part of the watershed tend to be larger, while the number of farms is decreasing across the watershed. A look at the farm financial activity shows that farms in the west tend to have slightly higher sales and expense activity, perhaps due to the larger hog industry in these subwatersheds. The western half of the watershed tends to rely less on commercial fertilizers than the eastern half, again likely due to the availability of manure, especially from pigs. The area of cropland and unimproved and natural pastures has been declining while increases were occurring in tame or seeded pastures; this corresponds to moderate increases in cattle numbers across the watershed as well. Tillage practices changed over the past 35 years with an increase in conservation or zero tillage and a decrease in summerfallowed and conventionally tilled areas. Increases were also noted to areas seeded to canola, alfalfa and pulse crops and decreases in cereal grains, most notable spring wheat.

Analysis of Land Cover over a 12-year period corresponds well with the Census data, particularly the conversion of annual cropland to forages and grasslands, which occurred at the same time as external drivers such as the elimination of the Western Grain Transportation subsidy. Analysis of soils under annual cropland showed trends toward improved management, with a decreasing amount of annual cropland on class 4 or lower, on lands with a severe or high wind erosion risk, and on imperfectly drained soils. Areas were identified and mapped within the watershed where the combination of annual cropping and landscape risk factors such as wind erosion, agricultural capability, and drainage indicate special management of these lands may be warranted. An examination of land cover data and agricultural capability was

undertaken to identify environmentally sensitive lands, such as ecologically valuable lands such as wetlands and treed areas that are vulnerable due to a higher potential for conversion to other uses such as crop production. The identification of annual cropland within a 50 m buffer to waterways that had a high or severe water erosion risk indicates a significant area that could contribute to water quality issues because of the likelihood of sediment and nutrient transport to nearby waterways. Due to data limitations, all geographic analyses using land cover and soils data require further verification such as groundtruthing for accuracy assessment.

The proactive nature of producers in the watershed to deal with environmental issues was demonstrated by their participation in the Canada-Manitoba Farm Stewardship Program (CMFSP) and the Environmental Farm Plan (EFP) Program (2003-2008). Further examination of program results revealed high levels of uptake in both programs; in fact they were among the highest in the province. As a result, 856 beneficial management practice (BMP) projects were completed from 2003 – 2008 by producers in the watershed that received financial and technical assistance through the CMFSP. Approximately half of these projects were related to non point source – crop related BMPs and another 169 projects involved non point source – livestock related BMPs.

Recommendations from the analysis to address drinking water quality and surface water quality issues include: the support for marginal land management options such as the adoption of BMPs for sustainable land management, water erosion mitigation practices such as grassed waterways, buffer establishment, and land conversion to forages, as well as promoting BMPs that will reduce nutrient transport to waterbodies. With respect to the surface water quantity issue, a water assessment and surface water management assessment study conducted on the entire watershed could be developed to understand where gains could be made for flood protection. In addition, an examination of potential wetland restoration project sites could be carried out to explore options for maintaining particular lands that provide environmental benefits for reducing impacts of drainage and flooding. Promotion or incentives for permanent cover are also recommended for those lands that are class 4 and lower, or are considered prone to wind or water erosion. Other BMPs such as the use of cover crops and residue management techniques, as well as shelterbelt establishment should be promoted where wind erosion is an issue. Potential indicators were also identified for each recommendation presented to allow the Integrated Watershed Planning Process to evaluate progress related to addressing the issue in the future.

B. Acknowledgements:

The following individuals contributed to the compilation, interpretation, and derivation of information contained in this submission.

AAFC-AESB: Holweger, U., Michiels, P., Powers, J., Vanrobaeys, J., Bogdan, D., Kopytko, M.

MAFRI: Gauer, E.

C. Preface

In 2008, the Pembina Valley Conservation District (PVCD) was designated as the Watershed Planning Authority to update a previously developed Integrated Watershed Management Plan (2005) for the Pembina River Watershed study area completed in 2005. In support of updating this plan, a Project Management Team (PMT) was formed to guide the watershed planning process. A formal request was made on behalf of the PMT and Manitoba Water Stewardship to Agriculture and Agri-Food Canada - Agri-Environment Services Branch (AAFC-AESB) and Manitoba Agriculture Food and Rural Initiatives (MAFRI) to provide technical support as it relates to their respective mandates (See Appendix A) in support of developing the plan.

This report focuses on information related to agricultural activities and land resources in the watershed. It is important to note that in addition to agriculture, there are other industries, sectors, and users of the watershed's resources that also have an impact on the watershed. As there are scale and accuracy limitations associated with the available data (including soils, land cover, and Census of Agriculture data), it should be noted that the information contained within this report does not replace the need for site-specific analysis; rather, it serves as a guide for general planning purposes in the Pembina River Watershed study area. More information on the data used in this document can be found within the Appendices.

D. Introduction

The Pembina River is a major watercourse located in south central Manitoba, and part of the larger Lake Winnipeg Basin. The Canadian portion of the Pembina River Watershed is approximately 488,257 ha in size (refer to Figure 1). Originating in the Turtle Mountains, the Pembina River flows in an easterly direction across southern Manitoba, connecting Rock Lake and Swan Lake, and continuing into North Dakota. After crossing the international border the river meanders east through northern North Dakota and meets up with the Red River, near Pembina, North Dakota. There are six major communities in the Canadian portion of the watershed including Boissevain, Killarney, Cartwright, Crystal City, Pilot Mound and Manitou. The total population in the Canadian portion of the watershed is approximately 15,600.

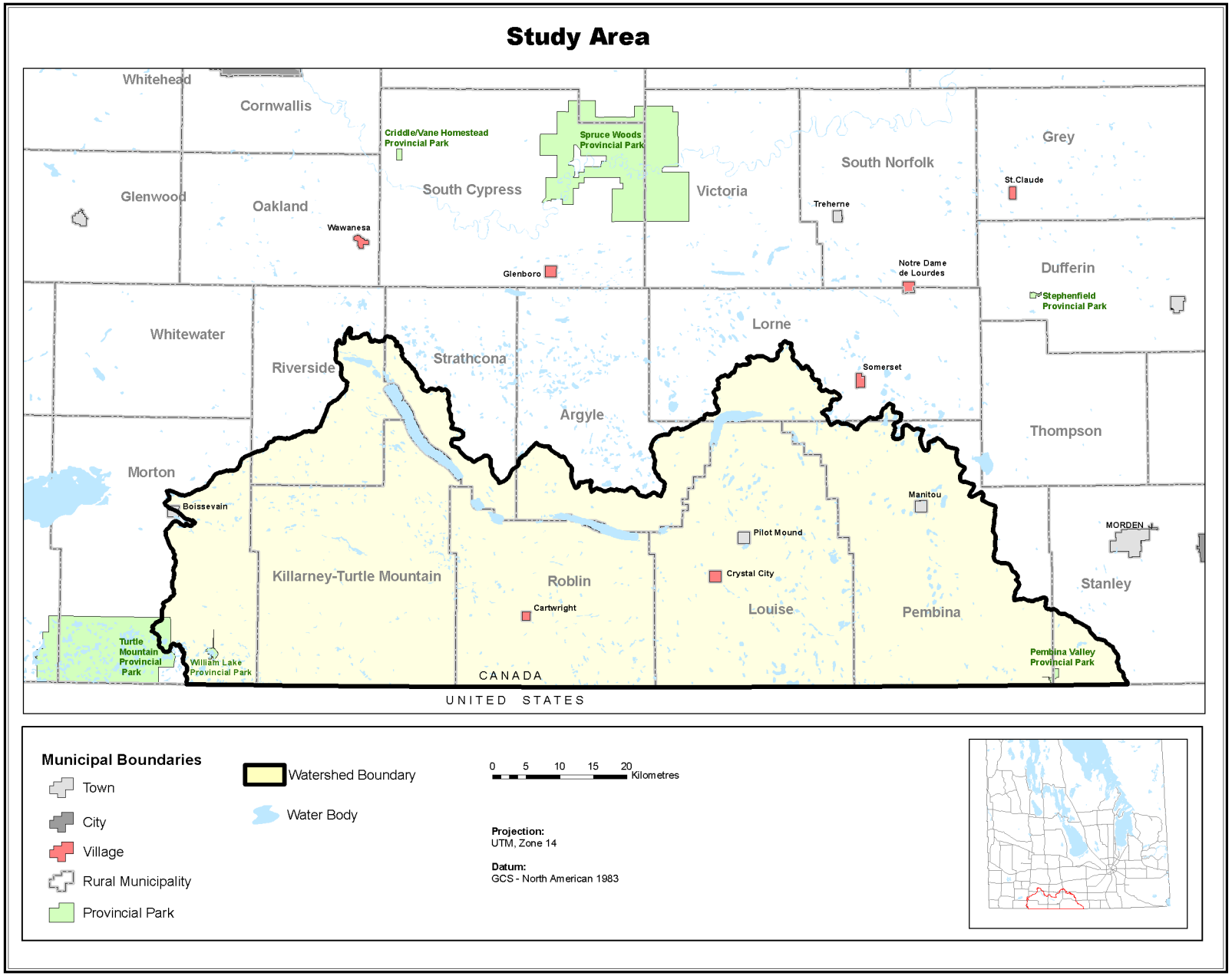
The Pembina River Integrated Watershed Management Plan (IWMP) Area is defined by the Canadian portion of the watershed boundary (Figure 1). The study area contains seven smaller but important subwatersheds as defined by Manitoba Water Stewardship (Figure 1). The physiographic and demographic features for these seven subwatersheds lend themselves to a grouping of four distinct regions for analysis in this report where data was available at this scale (Figure 2).

Objective

Understanding the current state and trends in agricultural land use and practices along with landscape characteristics is essential for developing an integrated watershed management plan. Agricultural land use and associated land cover can influence watershed processes and impact issues like water quality and hydrological flow within the watershed. Understanding these factors contributes to developing sustainable land use strategies that will lead to a healthier and more ecologically functioning landscape. To better understand agricultural changes and impacts within the watershed, PFRA and MAFRI partnered to analyze agricultural aspects, focusing on the major issues identified in the 2008 public consultations pertaining to the IWMP. **Specifically, the document will examine the following in order to help guide watershed management:**

1. **"Near-Current" Agricultural Land Use and Management using the latest available Census of Agriculture data and satellite imagery**
2. **Trends in agricultural land use and management using 1971 to 2006 Census of Agriculture data and a time series of satellite imagery**
3. **Land cover data in combination with landscape risk factors pertaining to the soil and water resource**
4. **The impact of recent federal and provincial initiatives, policies and regulations impacting agricultural land management and land use planning activities in the watershed**

Figure 1: Pembina River Watershed Study Area



E. Agricultural Land Use and Management

i. Current Agricultural Land Use of the Pembina River Watershed Study Area

a) Agricultural Profile of the Pembina River Watershed

Agricultural profiling refers to the characterization of agricultural production in an area or a region. Census of Agriculture information collected from producers can provide a snapshot in time of the agricultural footprint on the landscape. The information can be portrayed either on a municipal or geographical boundary (like a watershed) and can provide value to understanding the practices and trends of the industry to the area.

Census of Agriculture data at a subwatershed scale has been obtained from Statistics Canada for the 2006 Census year. Further details on the method used to interpolate Statistics Canada's Census of Agriculture from a geographic boundary to a subwatershed boundary are provided in Appendix B. For reporting purposes, numbers have been rounded to the nearest 5 for farm numbers, 10 for livestock and for data in smaller areas, and 100 for poultry, financial data and for data in larger areas.

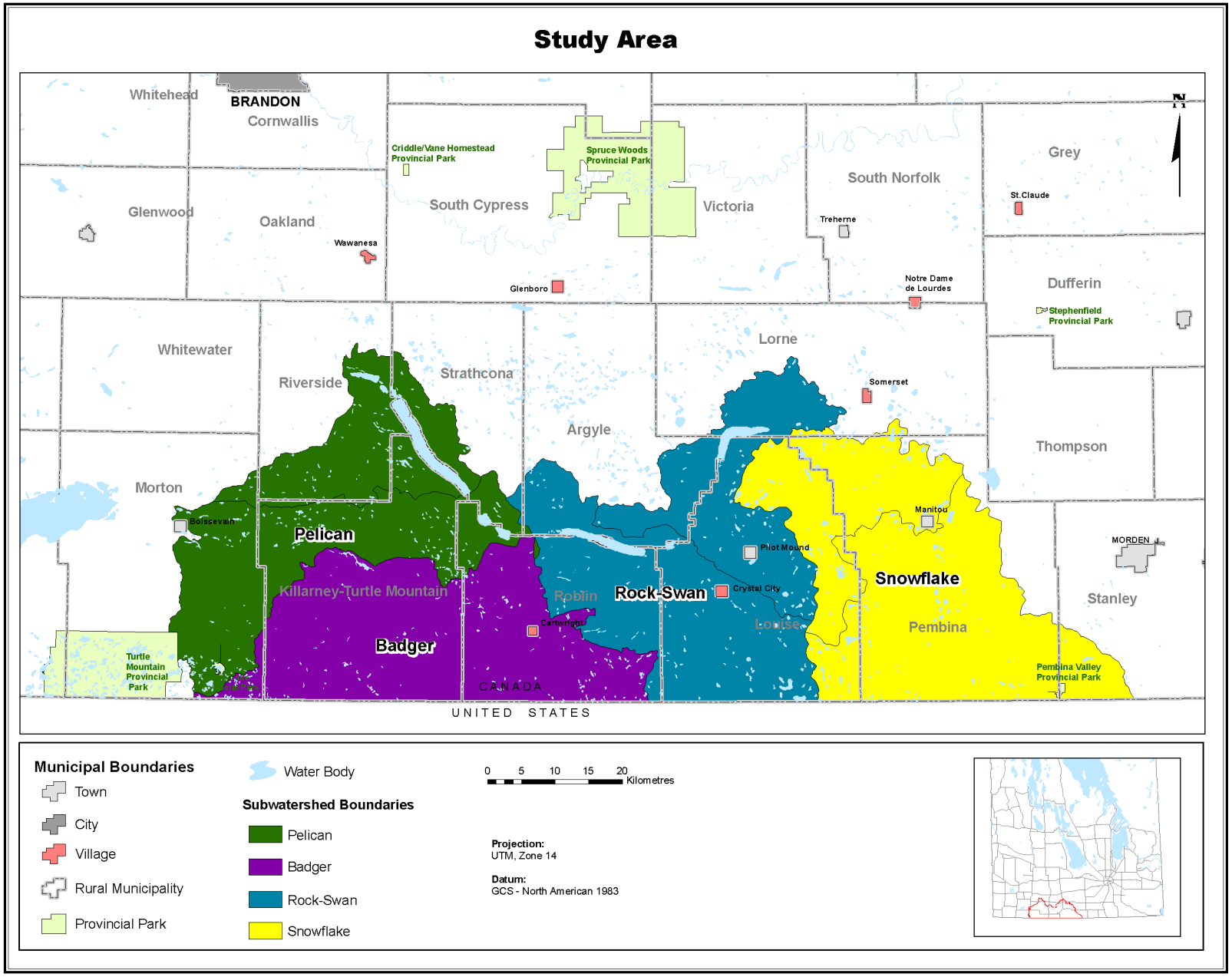
In the Pembina River Watershed, there are 7 subwatersheds for which 2006 Census data is available. For the purpose of this report, these 7 subwatersheds have been grouped into 4 are subwatershed type areas as delineated in Figure 2. The Pelican Subwatershed includes areas that drain into the headwaters of the Pembina River, Pelican Lake, as well as the Lorne and Louise Lakes. The Badger Subwatershed refers to the area that drains into the Long River and Badger Creek. The Rock-Swan Subwatershed is the area drained by the Cypress and Chrystal Creeks, as well, as Swan Lake and Rock Lake. The Snowflake Subwatershed refers to the area in Manitoba drained by the eastern part of the Pembina River. Table 1 lists these subwatersheds with their respective sizes.

Table 1 - Watershed Groupings

Subwatershed name	Area (hectares)	Percent of Pembina River Watershed
Pelican	116,354	24%
Badger	104,551	21%
Rock-Swan	131,297	27%
Snowflake	136,053	28%

In the two subsequent sections, a profile of land use and land management, as well as farm financial characteristics, will describe agricultural activities in each of these four subwatersheds. Comparisons of these profiles follow each section and will provide an understanding of the differences in the agricultural industry within the Pembina River Watershed.

Figure 2: Subwatershed Groupings for the Agriculture Profile (2006 Census of Agriculture)



Summary of Land Use and Land Management

Pelican Subwatershed:
According to the 2006 Census of Agriculture data, over 65% of the farmland in the Pelican Subwatershed was dedicated to annual crop production and almost 30% to pasture, alfalfa, and hay and fodder crops. Cereals made up half of the cultivated land while over 30% was seeded to oilseeds. Pulse crops made up less than 5% and forages over 10%. Land management practices included almost 30% of the cultivated land managed using conventional tillage practices, almost 55% using conservation tillage practices and 20% prepared with zero tillage. Almost 15 farms reported poultry with an average flock size of about 400 birds per farm, for a total of over 5,100 birds in the subwatershed. Over 10 operations had pigs, with an average of almost 5,200 animals/farm; a total of over 60,000 pigs reported. Five farms reported sows with an average of almost 1130 sows per farm. As for dairy, fewer than 5 operations reported dairy cows. With respect to beef cattle, 115 farm operations reported beef cows, with an average of almost 65 cows per farm. Total cattle and calves in the area added up to almost 18,100 animals.

Badger Subwatershed:
In 2006, almost 65% of the farmland in the Badger Subwatershed was dedicated to annual crop production and another 30% to pasture, alfalfa, and hay and fodder crops. Cereals made up 50% of the cultivated area and oilseeds almost 30%. Pulse crops made up less than 5% and forages over 10%. Land management practices included almost 35% of the cultivated land managed using conventional tillage practices, 45% using conservation tillage practices and over 20% prepared with zero tillage. Over 10 farms had poultry with an average flock size of less than 1,200 birds per farm for a total of over 13,000 birds reported. Over 15 operations reported pigs with an average of 4,190 animals/farm; over half of these farms also had sows with an average of almost 780 sows per farm. As for dairy, 5 operations reported an average of almost 60 dairy cows per farm. In addition, almost 120 of the farm operations in the subwatershed had beef cows with over 70 cows per farm. Total cattle and calves reported in the area added up to almost 19,900 animals.

Rock-Swan Subwatershed:
In the Rock-Swan Subwatershed, about 65% of the farmland was dedicated to annual crop production and almost 30% to pasture, alfalfa, and hay and fodder crops. Cereals made up half of the cultivated land while almost 35% was seeded to oilseeds. Pulse crops made up less than 5% and forages almost 15%. Land management practices included almost 40% of the cultivated land prepared using conventional tillage practices, 40% using conservation tillage practices and 20% prepared with zero tillage. Almost 10 farms reported poultry with an average flock size of over 2400 birds per farm, for a total of around 41,500 birds in the subwatershed. Almost 25 operations had pigs, with an average of almost 1,830 animals/farm; a total of around 41,500 pigs reported. Over 10 farms reported sows with an average of almost 300 sows per farm. As for dairy, almost 10 operations had dairy cows with an average of almost 40 cows per farm. With respect to beef cattle, 160 farm operations had beef cows, with an average of just over 70 cows per farm. Total cattle and calves reported in the area added up to almost 25,700 animals.

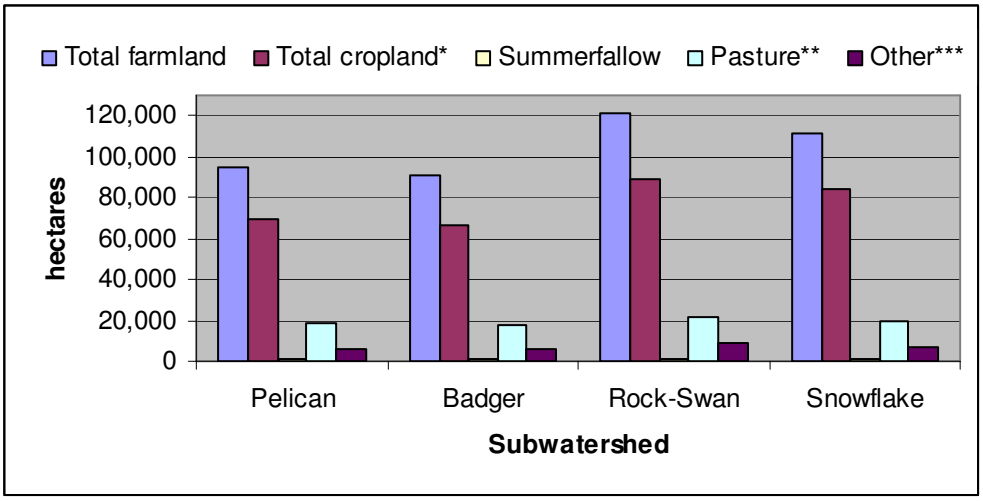
Snowflake Subwatershed:
In the Snowflake Subwatershed, over 65% of the farmland was dedicated to annual crop production and another 25% to pasture, alfalfa, and hay and fodder crops. Cereals made over 45% of the cultivated area and oilseeds around 35%. Pulse crops made up less than 5% and forages over 10%. Land management practices included over 55% of the cultivated land prepared using conventional tillage practices, less than 35% using conservation tillage practices and just over 10% prepared with zero tillage. Over 15 farms had poultry with an average flock size of over 6,600 birds per farm for a total of over 108,000 birds reported. Ten operations had pigs with an average of about 1,900 animals/farm; a total of over 57,700 pigs reported. All of these farms reported sows with an average of almost 600 sows per farm. As for dairy, fewer than 10 operations reported an average of almost 55 dairy cows per farm.

In addition, almost 155 of the farm operations in the subwatershed had beef cows with over 60 cows per farm. Total cattle and calves reported in the area added up to over 21,100 animals.

Subwatershed Comparison:
In comparing the four sub-watersheds, although Rock-Swan and Snowflake are larger in area, all four had a similar proportion of each land use type in a subwatershed (refer to Figure 3). In all four subwatersheds, 75% of the area was used for cropland, 1% for summerfallow, almost 20%for pasture and 6% for other land uses.

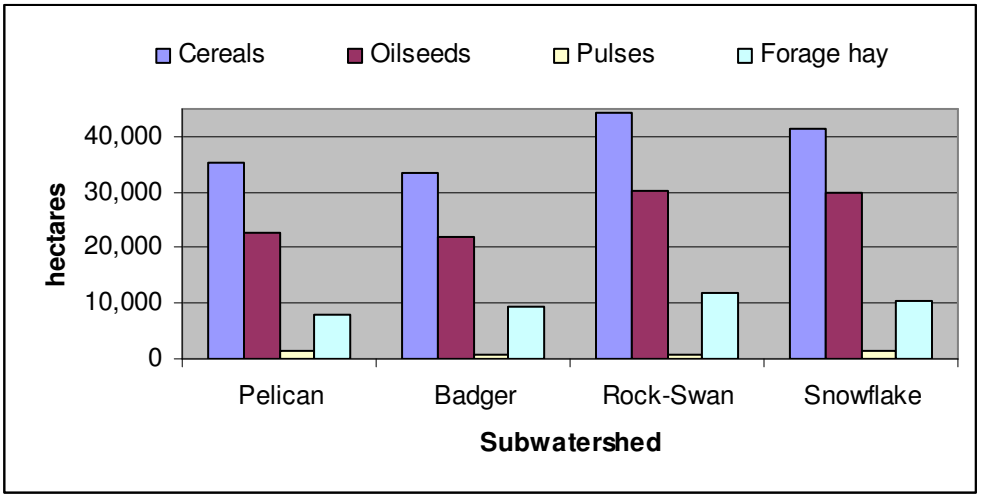
A similar pattern emerges when breaking down the cropland to the major crop types grown in 2006. Around half of the cropland was dedicated to cereals, another third to cereals, around 2% to pulses, and 11% to 14% to forages (refer to Figure 4). Some differences within the crop type occur between the subwatersheds. Canola made up 90% of the oilseeds in Pelican and Badger, and slightly less in Rock-Swan at 85%. As for Pulses, dry field peas made up the majority (over 80%) of pulses grown in Pelican and Badger, whereas soybeans made up over 90% of the pulses grown in Rock-Swan and Snowflake.

Figure 3 - Distribution of Agricultural Land Use in 2006



* Total cropland includes all field crops, vegetables, fruit and nuts and sod
** Pasture includes tame pasture and natural areas used for pasture
*** Other category includes all other land uses including farmyard, woodlots, Christmas trees, wetlands, etc.

Figure 4 - Distribution of the main crop types in 2006



With respect to crop inputs, the proportion of area with fertilizer applications, as well as pesticides, was also similar in all four subwatersheds (refer to Figure 5).

With respect to seedbed preparation, there was a difference in tillage practices across the Pembina watershed. In the western part of the watershed, tillage practices tended to be dominantly conservation with approximately 75% of the cropland managed using conservation and zero tillage practices. In the eastern part, just over half of the cropland was prepared using conservation and zero tillage (refer to Figure 6).

Figure 7 summarizes the livestock numbers in the Pembina River Watershed. The livestock and poultry industry is important in all four subwatersheds, with the most poultry reporting in Snowflake. Pigs were also raised in all four areas, with slightly more animals in the western part. Sows made up 10% of the total pigs in Snowflake and Pelican, and less than 10% in the central subwatersheds. As for cattle, beef production is important in all four subwatersheds, where beef cows made up over 40% of the total cattle and calves. Dairy production does occur, though less than 10 farms reported dairy cows in all four subwatersheds.

Figure 5 - Area treated to crop inputs in the 2005 crop year (as reported in the 2006 Census)

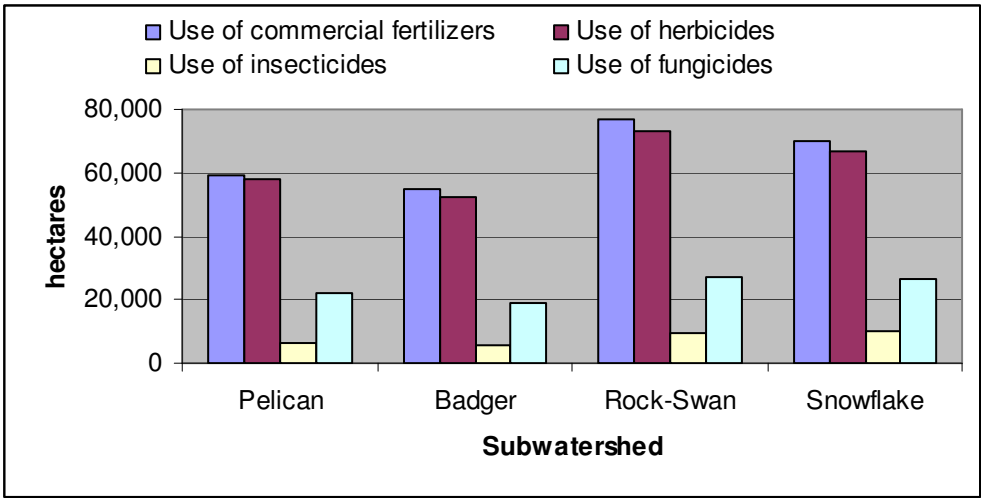


Figure 6 - Tillage practices in the Pembina River Watershed in 2006

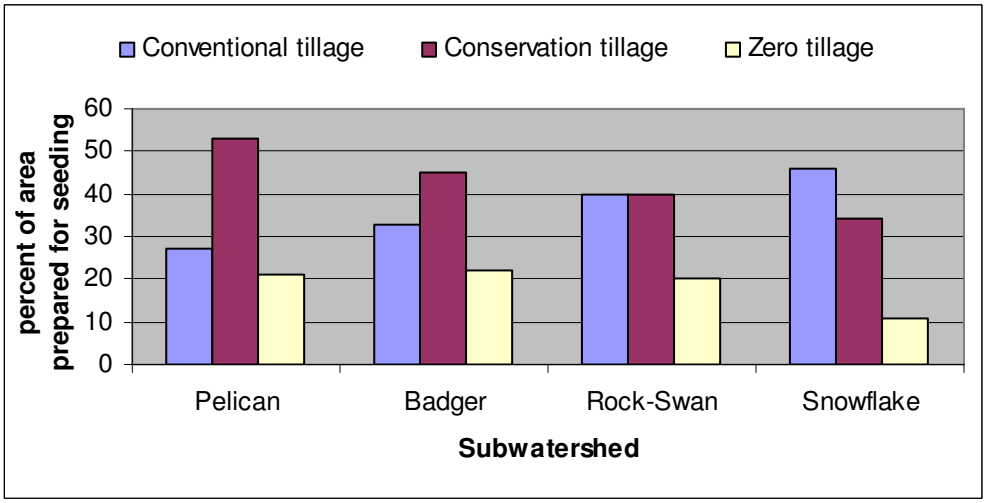
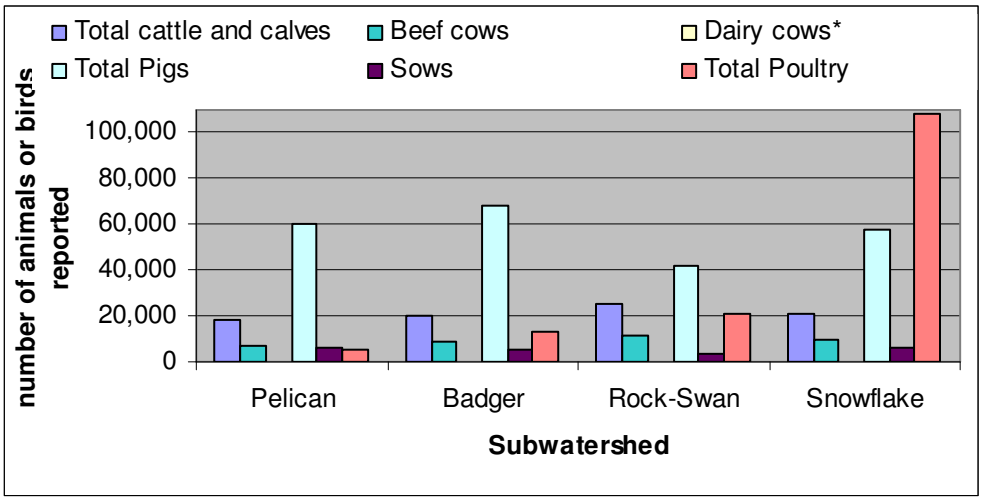


Figure 7 - Total livestock and poultry numbers in the Pembina River Watershed in 2006[1]



1 – Totals are number of animals that were on the farm on the day of Census survey
* Some suppression of dairy cow numbers occurs in Rock-Swan and Snowflake subwatersheds, and all dairy cow numbers suppressed for Pelican subwatershed

Total Animal Units (AU) produced in the watershed (based on annual nitrogen production) have been estimated using Manitoba's AU coefficients and by making several assumptions about these animal units (Appendix C). As presented in Table 2, cattle and calves, consisting mainly of beef cattle, contributed the majority of animal units produced in each of the subwatersheds. Since beef production consists of mainly cow/calf operations, manure nitrogen (and phosphorous) will be naturally deposited on pastureland by the animals during the grazing season, and accumulated in more concentrated areas during the winter season. Cattle production in the Rock-Swan subwatershed make up over 70% of the total AU produced in the subwatershed. Pigs contribute to around 30% of the AU in each of Pelican, Badger and Snowflake. Hog production generally consists of intensive confined livestock production with the manure produced by the animals stored in manure storage structures and spread out on nearby fields. Poultry production, most of which takes place in the Snowflake subwatershed, make up a very small proportion of the Total Animal Units.

Table 2 - Estimated Annual Animal Units produced in Pembina (according to the number of livestock reported on Census day, 2006)

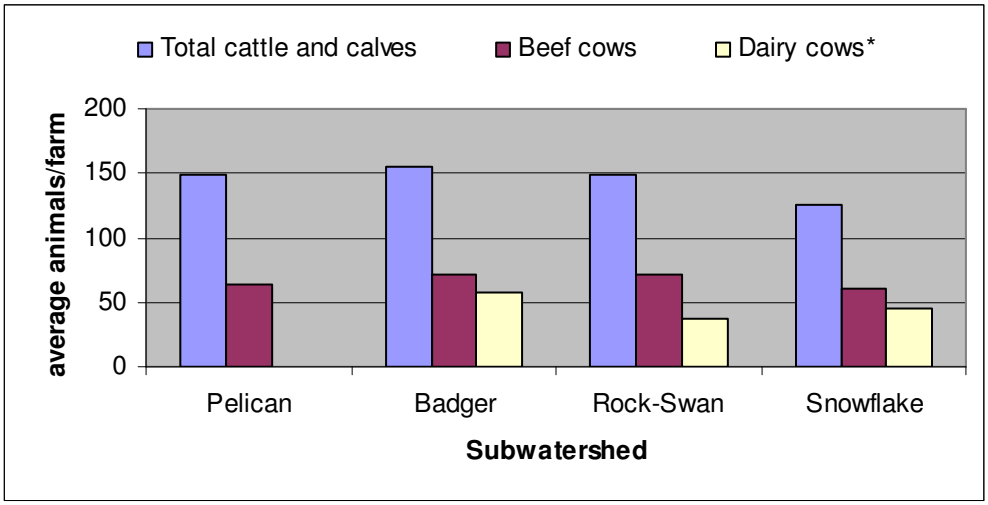
Livestock Type	Animal Units (AU)				Pembina Total Animal Units
	Pelican	Badger	Rock-Swan	Snowflake	
Total Cattle and Calves	11,122	12,861	16,571	13,807	54,361
Total Pigs	6,504	7,790	5,162	5,955	25,410
Total Poultry	17	x*	0	574	591
Total Horses and Ponies	468	502	576	320	1,867
Other livestock - sheep, goats, bison, elk)	96	x*	190	194	481
TOTAL AU	**18,208**	**21,152**	**22,499**	**20,851**	**82,710**

* livestock numbers have been suppressed to preserve confidentiality of the Census data

Intensity of the livestock industry can be determined by the average size of flocks and herds. Farms in the Snowflake subwatershed tend to have slightly less total cattle and calves as well as beef cows than farms in the other three areas (Figure 8). For pig production, farms in the Pelican and Badger

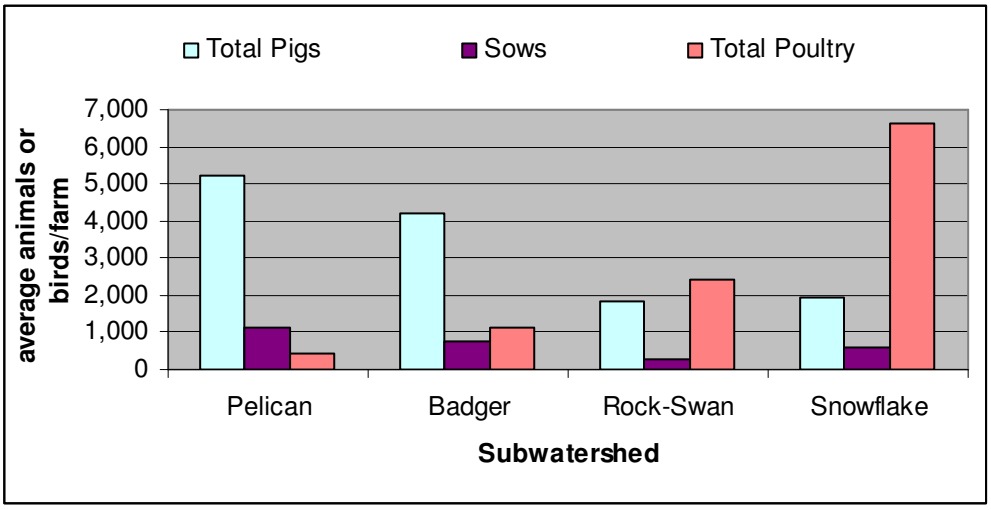
subwatersheds had larger barns (3000-5000 pigs/farm) on average than those in the eastern area (where the average was under 2000 pigs/farm) (Figure 9). For poultry production, farms in the Snowflake area had the largest poultry barns, with over double the number of birds per farm compared to the other subwatersheds.

Figure 8 - Average cattle herd size in the Pembina River Watershed in 2006



* Some suppression of dairy cow numbers occurs in Rock-Swan and Snowflake subwatersheds, and all dairy cow numbers suppressed for Pelican subwatershed

Figure 9 - Average number of pigs or poultry per farm in 2006



Summary of Farm Financial Characteristics

Pelican Subwatershed:

The Pelican Subwatershed makes up 24% of the Pembina River Watershed. In 2006, over 82% of the subwatershed was being used by 205 operations for farming purposes. Generally, the average farm size was almost 465 ha/farm (1,150 acres) with an average capital investment of almost $2,400 per hectare of farmland (or $1,122,600 per farm). Livestock-related expenses per hectare of farmland were over $105/ha of farmland, while crop-related expenses were almost $160/ha. Per farm, profit was estimated to be almost $34,500 and the sales to expense ratio was reported to be 1.16 (farm operations received $1.16 gross revenue for every $1 of agricultural expense).

Badger Subwatershed:
In the Badger Subwatershed, over 210 farm operations managed an area of farmland equivalent to over 75% of the subwatershed area. Generally, the average farm size was almost 430 ha/farm (1060 acres) and farms had an average capital investment of $2,400 per hectare or $1,011,900 per farm. Average livestock-related expenses per hectare of farmland were over $65/ ha farmland, while crop-related expenses were almost $115/ha. Per farm, profit was estimated to be over $28,500 and the sales to expense ratio was reported to be 1.16.

Rock-Swan Subwatershed:
The Rock-Swan Subwatershed makes up 27% of the Pembina River Watershed. In 2006, there were almost 295 farms using almost 75% of the Subwatershed area for farming purposes. Generally, the average farm size was almost 410 ha/farm (1015 acres) with an average capital investment of almost $2,470 per hectare of farmland (or $1,012,200 per farm). Livestock-related expenses per hectare of farmland were $85/ha of farmland, while crop-related expenses were almost $180/ha. Per farm, profit was estimated to be almost $32,800 and the sales to expense ratio was reported to be 1.18.

Snowflake Subwatershed:
In the Snowflake Subwatershed, almost 325 farm operations managed an area of farmland equivalent to over 80% of the subwatershed area. Generally, the average farm size was around 345 ha/farm (855 acres) and farms had an average capital investment of over $3,000 per hectare or $1,054,500 per farm. Average livestock-related expenses per hectare of farmland were almost $115/ ha farmland, while crop-related expenses were almost $180/ha. Per farm, profit was estimated to be almost $27,500 and the sales to expense ratio was reported to be 1.16.

Subwatershed Comparison:
In comparing the four sub-watersheds, there is a trend of farms being larger in the west than in the eastern portion of the watershed. As well, while farms were smaller in the east, there were more of them, whereas the opposite is true in the west; there were fewer but larger farms in the western part (Figure 10). A look at the farm financial activity shows that farms in the west tend to have slightly higher sales and expense activity, perhaps due to the larger hog industry in these subwatersheds. Estimated profit per farm was highest in Pelican and lowest in Snowflake (Figure 11).

Livestock and Crop-related expenses reported for the 2005 crop year have been determined on a per hectare basis. Figure 12 shows that on average, farm operations had slightly higher expenses for crop production in Rock-Swan and Snowflake, whereas livestock operations in Pelican and Snowflake had, on average, higher expenses per hectare. A closer look at the crop input costs shows that farms in Snow-Rock and Snowflake spent more on fertilizer per ha compared to the other two (refer to Table 3). With respect to pesticides, farms in the Pembina watershed spent a similar amount of dollars per hectare

Figure 10 - Total number of farms and average farm size in the Pembina River Watershed in 2006

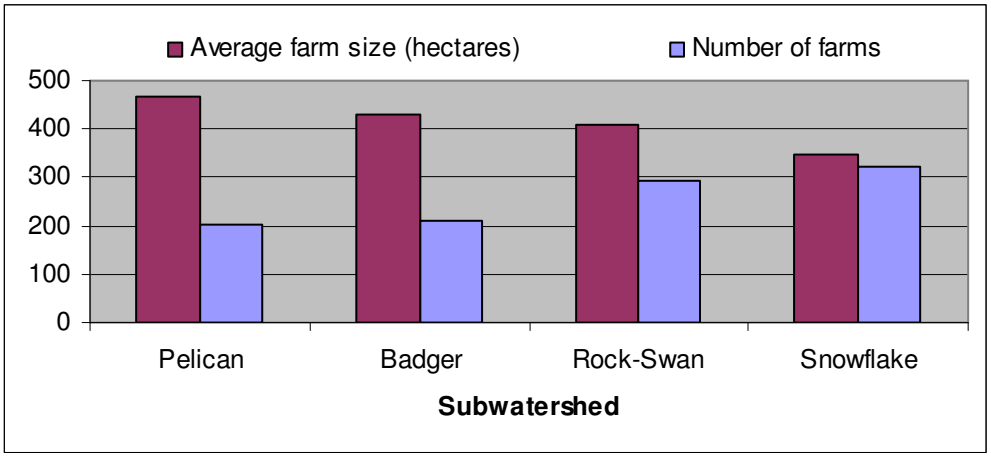


Figure 11 - Summary of farm financial activity in 2005 (as reported in the 2006 Census)

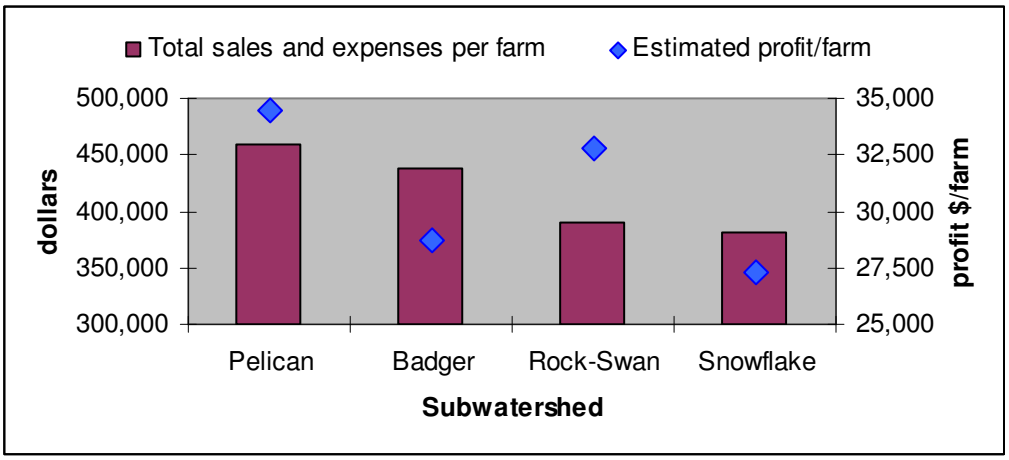


Figure 12 - Average livestock and crop-related expenses per hectare for the 2005 cropping year (as reported in the 2006 Census)

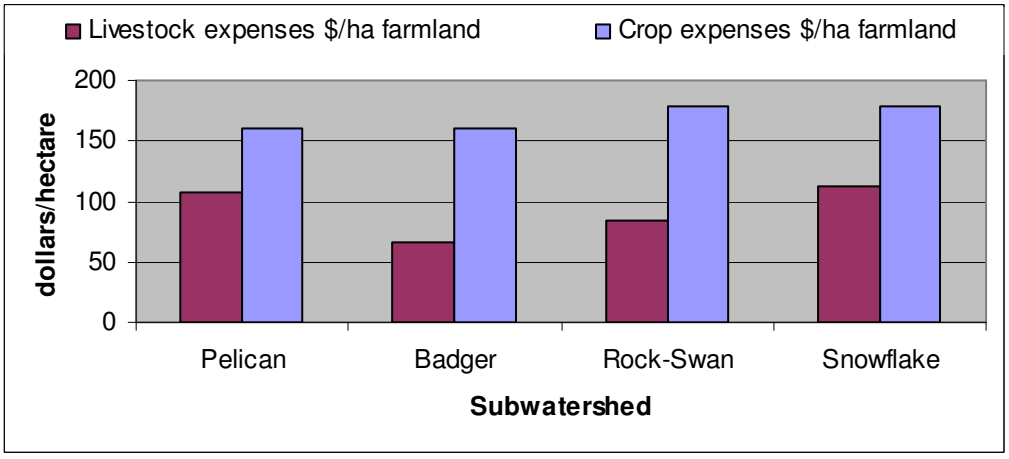


Table 3 – Average dollars per hectare spent on fertilizer and pesticides in the 2005 cropping year

Subwatershed name	Dollars spent on fertilizer per hectare applied	Dollars spent on pesticides per hectare applied
Pelican	$75	$46
Badger	$78	$47
Rock-Swan	$100	$50
Snowflake	$102	$49

2006 Agriculture Profile Summary

Agricultural activity is fairly uniform across the watershed with respect to agricultural land uses and crop types. One difference with respect to crops is that, in the western half of the watershed, pulses tended to be mainly dry field peas, whereas in the eastern half, soybeans dominated. With respect to livestock, the cattle industry is fairly uniform (though Badger has the lowest livestock-related expenses/ha than the other subwatersheds). Pig farms in the western half tend to have larger herds, whereas Snowflake has the majority of the poultry in the watershed, as well as the largest barns.

While there were fewer farms in the western half of the watershed, they tend to be larger than those in the eastern part. Farms in the Pelican subwatershed had a slightly higher estimated profit than that of the other three. The western half of the watershed tends to rely less on commercial fertilizers than the eastern half, perhaps due the higher number of pigs in the area.

b) 2006 Land Cover Summary

Land cover data used in this analysis was derived from 30 metre resolution LANDSAT Thematic Mapper satellite imagery. The land cover data provides information on the spatial extent of general types of land cover within a given area at that point in time. Further details on the land cover data, acquisition dates and the constraints associated with this data are provided in Appendix D.

Summary of 2006 Land Cover

Agriculture is the primary land use in the Pembina watershed and this is exemplified in the land cover data. In 2006, over half (283,594 ha or about 58%) of the land was classified as annual cropland (Table 4, Figures 13 and 14). Grassland/pasture areas cover almost 20% (or 86,722 ha) of the watershed and are more prevalent in the western subwatersheds (Pelican and Badger). Forage land cover, usually indicative of alfalfa stands, makes up about 4% of the watershed and is most common in the eastern subwatersheds (Rock-Swan and Snowflake). Treed areas occupy about 10% of the watershed and are mainly found in large tracts along the Pembina River, especially in the Snowflake subwatershed. A large treed area can also be found in the extreme southwest portion of the Pelican and Badger subwatersheds corresponding to the Turtle Mountain landscape. Wetlands occupy significant portions of the watershed (approximately 4%) and are significantly more common in the westernmost subwatersheds (Pelican and Badger). Approximately 3% of the watershed can be classified as water, consisting mainly of the three largest lakes (Pelican, Rock and Snow). Because there are few large communities in the watershed, land classified as urban (which includes transportation features such as roads and highways) occupies the least amount of the watershed accounting for only approximately 3% of the watershed.

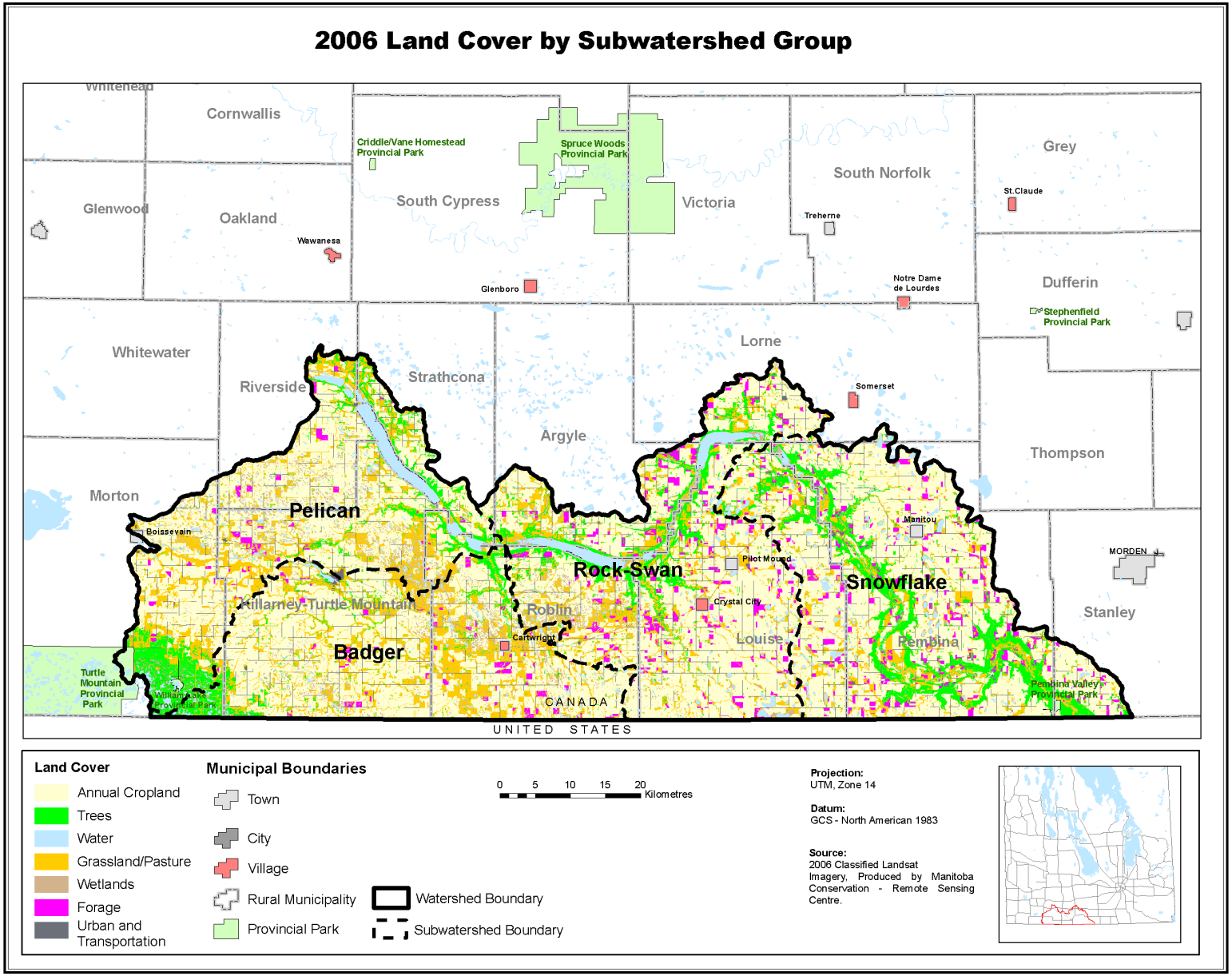
Table 4 - 2006 Land Cover by Subwatershed (in hectares)*

Subwatershed	Annual Cropland	Trees	Water	Grassland/Pasture	Wetlands**	Forage	Urban
Pelican	60,885	12,911	6,425	24,260	7,051	1,609	3,089
Badger	62,144	6,117	1,569	24,084	5,849	1,954	2,800
Rock-Swan	78,398	11,487	4,634	20,546	5,122	7,238	3,690
Snowflake	82,213	20,579	1,759	17,831	2,288	7,687	3,561
Pembina	**283,640**	**51,094**	**14,387**	**86,722**	**20,310**	**18,488**	**13,140**

* Area totals are approximate due to the nature of the image analysis procedure
** Due to seasonal changes in wetland size, date of imagery will affect area

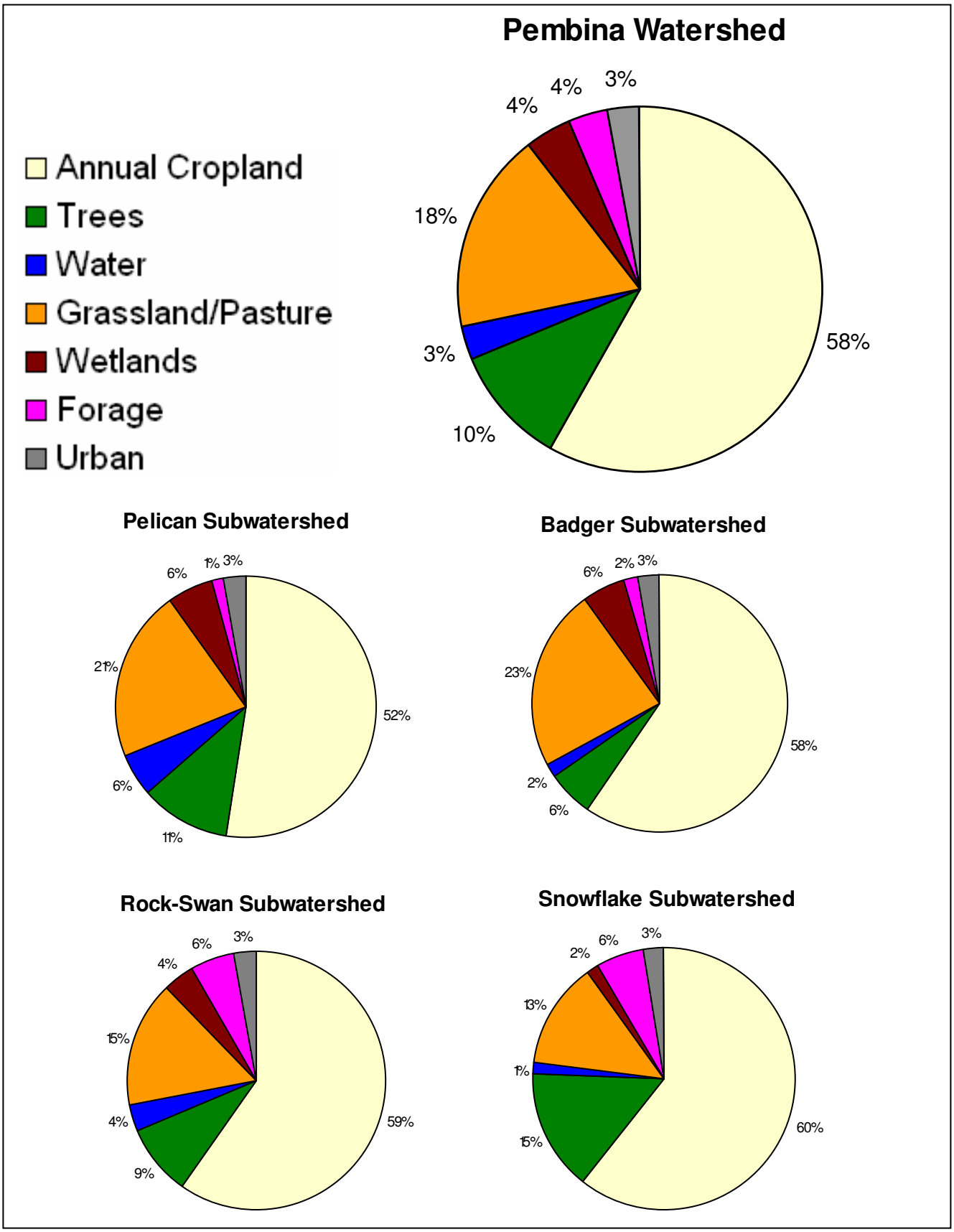
It should be noted, that, in 2005, Environment Canada weather stations in the study area recorded rainfall amounts that were significantly higher than the 15-year average, whereas 2006 was a much drier year. The amount of precipitation can affect some of the land cover at the time when the satellite imagery was taken, especially for areas of open water, wetland, and grassland.

Figure 13 - 2006 Land Cover in the Pembina River Watershed*



*The majority of the watershed land cover was derived from satellite imagery captured July 14, 2006, however a small portion in the southeast corner of the watershed was from June 16, 2005.

Figure 14 - Distribution of Land Cover within the Pembina River Watershed in 2006



ii. Agricultural Land Use Trends

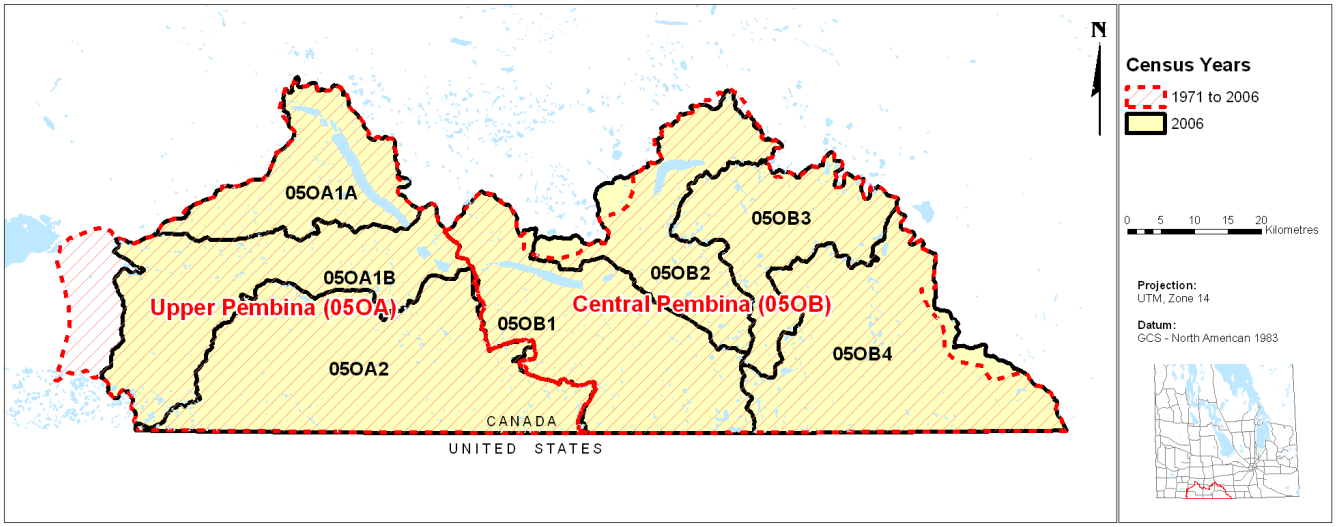
Agricultural land use is dynamic and there are many factors influencing changes over time. The factors vary from economic drivers like commodity prices, land values, input costs, and government programs to social influences like changing demographics and increasing environmental awareness. Changes in land use can have an environmental and economic impact on the health of a watershed. By assessing anticipated changes, land use trends can be useful for guiding the development of future programs and actions to encourage sustainable resource management in the watershed.

Census of Agriculture – 1971 to 2006

Census of Agriculture data has been obtained from Statistics Canada for the Census years from 1971 to 2006 and has been interpolated on a national scale to the Water Survey of Canada Sub-Sub Drainage Area boundaries. Further details on the method used to interpolate Statistics Canada's Census of Agriculture from a geographic boundary to a subwatershed boundary are provided in Appendix B.

In the Pembina River watershed, there are 2 sub-sub drainage areas that have Census of Agriculture data dating back to 1971 (Figure 15). In this section of the report, the western subwatershed will be referred to as Upper Pembina (about 239,000 ha) and the eastern subwatershed as Central Pembina (about 258,000 ha). Although the boundaries of the Census of Agriculture data differ slightly from the actual watershed boundaries, the data is still applicable for characterizing long term trends. For reporting purposes, numbers have been rounded to the nearest 5 for farm numbers, 10 for livestock and smaller area data, and 100 for poultry and for larger area and financial data.

Figure 15 – Watershed Boundaries for 1971 to 2006 Census of Agriculture Data



Land Cover – 1994, 2000, 2006

Land cover maps used in this analysis were developed using raster-based data sets derived from 30 metre resolution LANDSAT Thematic Mapper satellite imagery. These data sets are point in time and allow users to see the spatial extent of general types of land cover within a given area over time. Further details on the information used for the land cover analysis and the constraints associated with this data are provided in Appendix D.

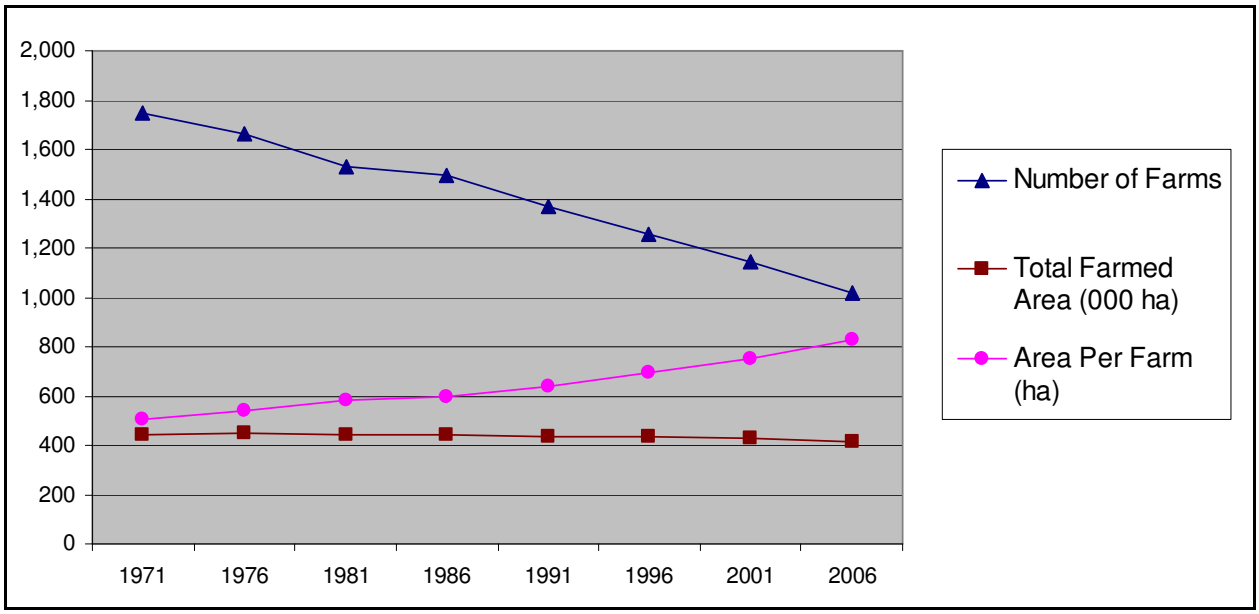
Land Use Change and Trends

Number of Farms and Farmed Area

The number of farms in the Pembina watershed has declined steadily from about 1,745 farms in 1971 to about 1,015 farms in 2006, a decrease of approximately 40% (Figure 16). As the amount of land farmed

in the watershed has declined slightly from about 441,000 ha to about 414,000 ha, the average size of these farms, in terms of area per farm, has increased steadily from about 250 ha to about 410 ha, an increase of about 60%.

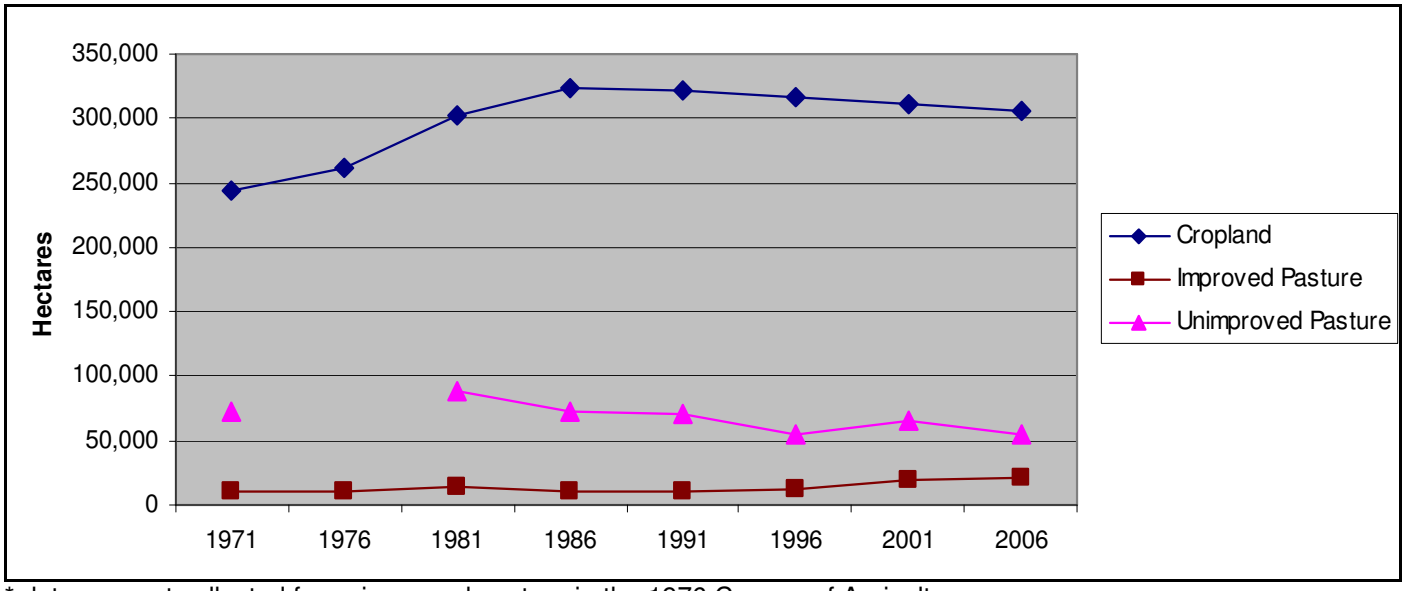
Figure 16 - Farm size in hectares, number of farms and total farm land in hectares in the Pembina River Watershed from 1971 to 2006



Cropland and Pasture Area

The area of cropland in the watershed has declined steadily since its 1986 peak of about 323,000 ha or approximately 65% of the watershed to about 308, 000 ha or approximately 62% of the watershed in 2006 (Figure 17). The area of improved pasture, otherwise known as tame or seeded pasture, has been increasing over that same 20 year period, from about 9,800 ha to about 21,900 ha. Unimproved, or natural, pasture has declined, since its 1981 peak of about 88,000 ha, to about 55,000 ha in 2006.

Figure 17 - Cropland and pasture area trends in the Pembina River Watershed from 1971 to 2006*

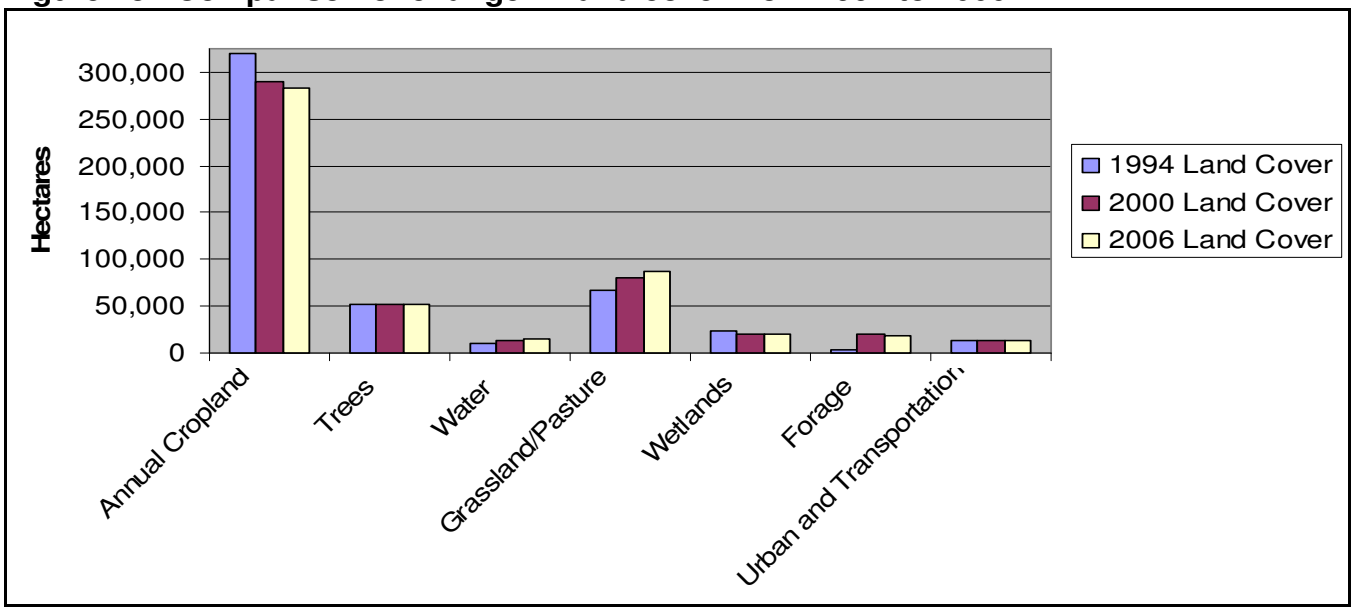


* data was not collected for unimproved pasture in the 1976 Census of Agriculture

Change in Land Cover

An analysis of land cover data from 1994, 2000 and 2006 satellite imagery supports the trends seen in the census data, with modest declines in cropland since the 1990s and an increase in grassland/pasture and forage classes over the same period (refer to Figure 18).

Figure 18 - Comparison of change in land cover from 1994 to 2006



Although there are some inherent limitations in utilizing land cover analysis methods to determine changes in land use, some changes can be noted:

- Annual cropland remains the predominant land cover type in the watershed with a 12% reduction in area between 1994 and 2006 (refer to Table 5).
- In correlation with the decrease in annual cropland, there is an increase in forages and grassland from 1994 to 2000. This can be attributed, in part, to the Permanent Cover Program (PCP) introduced in the early 1990s to encourage the conversion of marginal lands for agriculture from annual crop production to perennial cover. The repeal of the Western Grain Transportation Act (WGTA) also influenced the conversion of annual cropland to forage production on marginal lands. Impacts of the PCP and the removal of the WGTA coupled with favourable exchange rates (higher Canadian dollar versus United States dollar) led to accelerated land conversion of both viable lower class and prime agricultural land to forages. In addition, during this time period, there was an increase in the number of cattle reported in the census data (see Figure 21), resulting in a higher demand for pasture and hayland.

Table 5 - Change in Land Cover from 1994 to 2000 to 2006

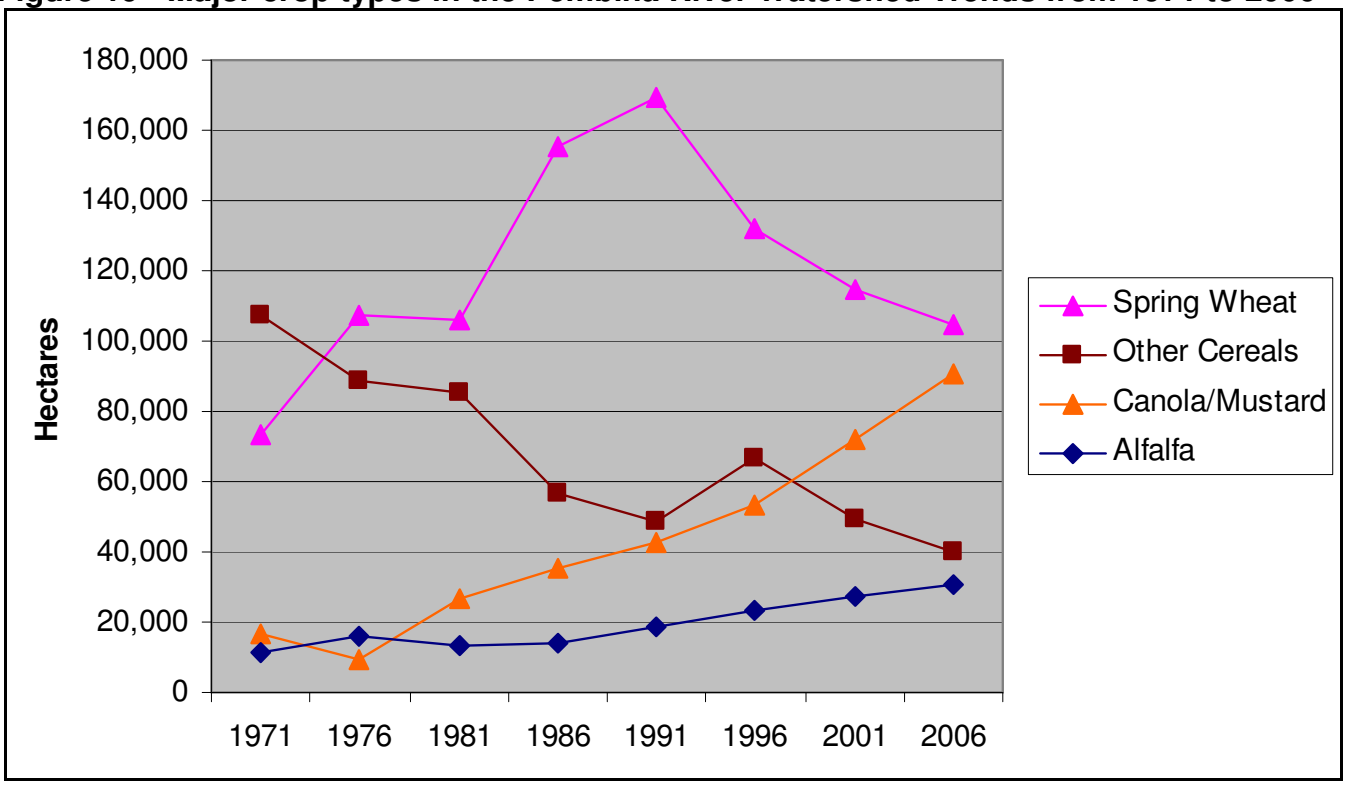
Land Cover	1994 Area (ha)	2000 Area (ha)	2006 Area (ha)	Percent Change[1] from 1994 to 2000	Percent Change[2] from 2000 to 2006
Annual Cropland	319,867	289,785	283,693	-9	-2
Trees	51,773	52,112	51,106	1	-2
Water	10,603	13,777	14,387	30	4
Grassland/Pasture	66,633	80,001	86,740	20	8
Wetlands	22,782	20,012	20,313	-12	2
Forage	3,582	19,482	18,491	444	-5
Urban/Transportation	13,023	13,010	13,143	0	1

1. Percent change is calculated as Year 2000-Year 1994/Year 1994 x 100
2. Percent change is calculated as Year 2006-Year 2000/Year 2000 x 100

Cropping Trends

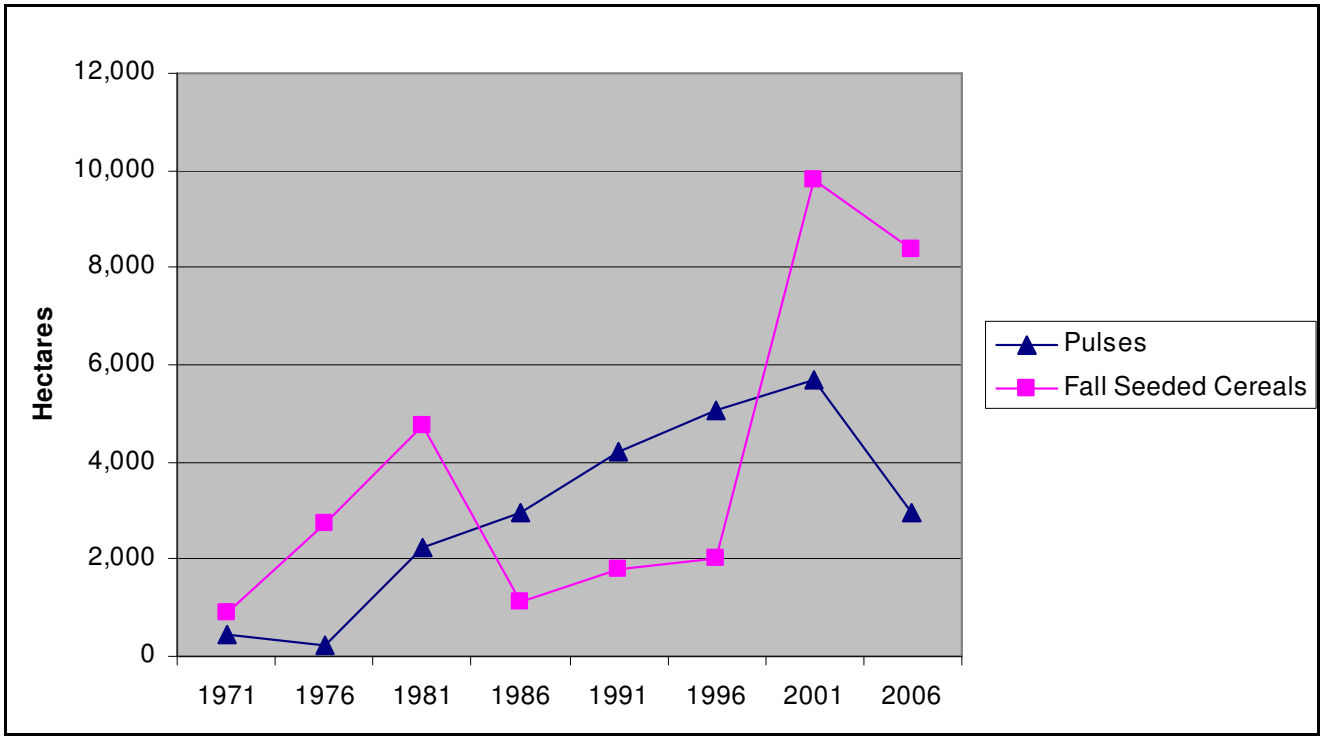
The area of land seeded to different crops from 1971 to 2006 has revealed some significant trends in the Pembina watershed (refer to Figure 19). The most dramatic shift has been the area used to produce canola/mustard where a dramatic increase since 1976, from just over 9,000 ha to over 90,000 ha in 2006 has taken place. The land seeded to alfalfa in the watershed has also increased during this period, from a low of about 12,000 ha in 1971 to about 30,000 ha in 2006. The gains seen in the area seeded to these crops has been offset by declines in area seeded to other crops and summerfallow. A closer look at the type of cereal grains grown in the watershed shows declines in spring wheat production since a 1991 peak of about 169,000 ha to about 105,000 ha in 2006. The amount of land in other cereals (includes barley, oats, mixed grains and spring rye) has declined since 1971 from about 107,000 ha to a about 40,000 ha in 2006. The amount of land in summerfallow has also declined significantly, from about 77,000 ha in 1976 to about 3,800 ha in 2006.

Figure 19 - Major crop types in the Pembina River Watershed Trends from 1971 to 2006



The amount of pulses and fall-seeded cereals grown has fluctuated significantly since 1971, but both types of crops have seen growth in area seeded since 1971 (refer to Figure 20). The amount of land in fall-seeded cereals (winter wheat and fall rye) has shown significant increases since 1986 from about 1,100 ha to a peak of about 9,800 ha in 2006. The majority (over 86%) of the approximately 3,000 ha seeded to pulse crops in 2006 was in the Upper Pembina subwatershed (05OA). Pulse crops seeded in the Central Pembina subwatershed (05OB) have been in a steady decline since a 1991 peak of about 2,800 ha, down to just over 400 ha in 2006.

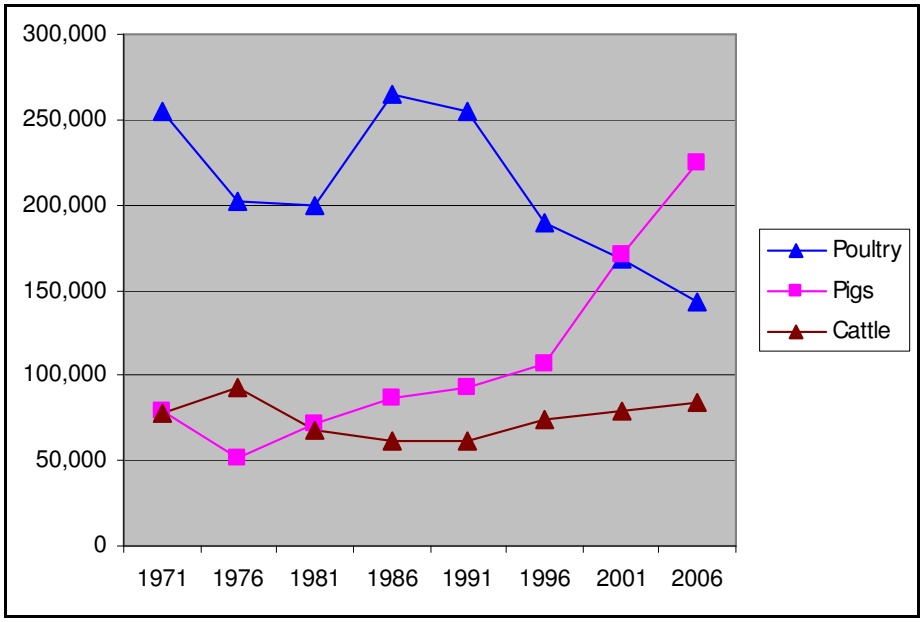
Figure 20 - Pulses and fall seeded cereals trends in the Pembina River Watershed from 1971 to 2006



Livestock Production

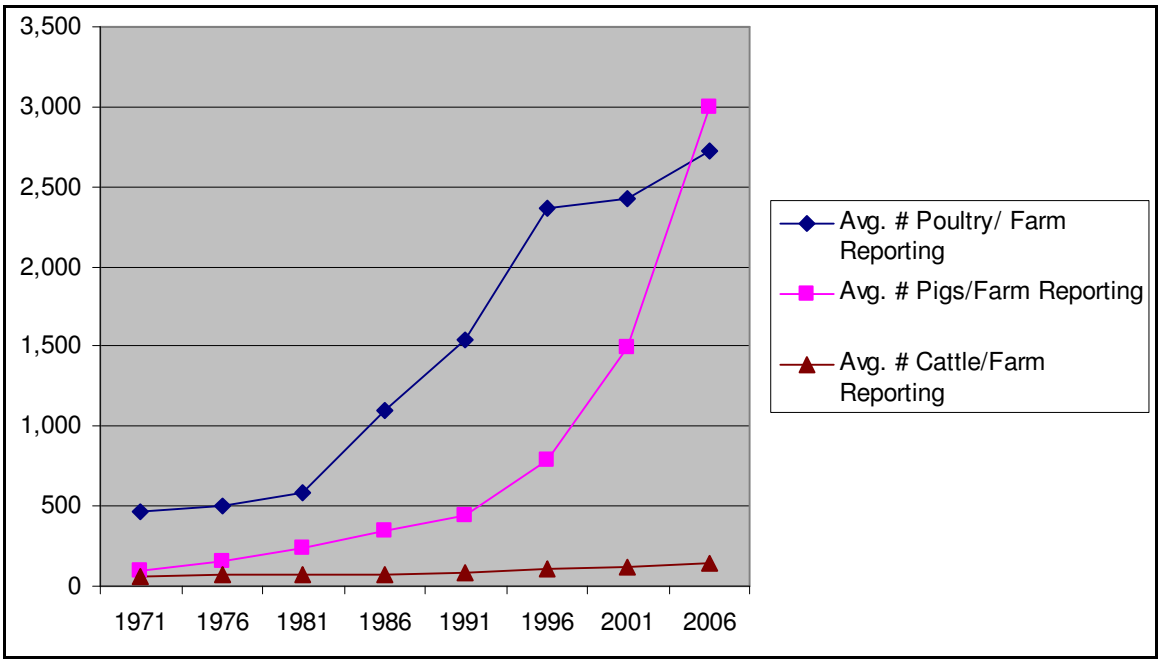
The amount of livestock and poultry produced in the watershed has varied during the 1971 to 2006 period (refer to Figure 21). The amount of pigs in the watershed has increased from about 77,000 in 1971 to about 225,000 in 2006. The amount of cattle in the watershed has fluctuated but has seen modest but steady increases since a 1986 low of about 61,000 head to about 84,000 head in 2006. In contrast, the amount of poultry raised in the watershed has declined since its 1986 peak of about 265,000 birds to about 143,000 birds in 2006.

Figure 21 - Major livestock production trends in the Pembina River Watershed from 1971 to 2006



The amount of livestock on an average farm in the watershed has been increasing since 1971. As one would expect, when the number of farms decline and the total amount of livestock increase, the average amount of livestock on a farm increases substantially (Figure 22). The amount of pigs per farm has increased most dramatically, from about 100 per farm in 1971 to almost 3,000 in 2006. Although leveling off in the last decade, the amount of poultry per farm has seen substantial increases over the 35-year period, from about 470 in 1971 to about 2,700 in 2006. The amount of cattle per farm has increased as well, from about 60 in 1971 to about 145 in 2006.

Figure 22 - Trend of the average number of livestock per farm reporting in the Pembina River Watershed from 1971 to 2006



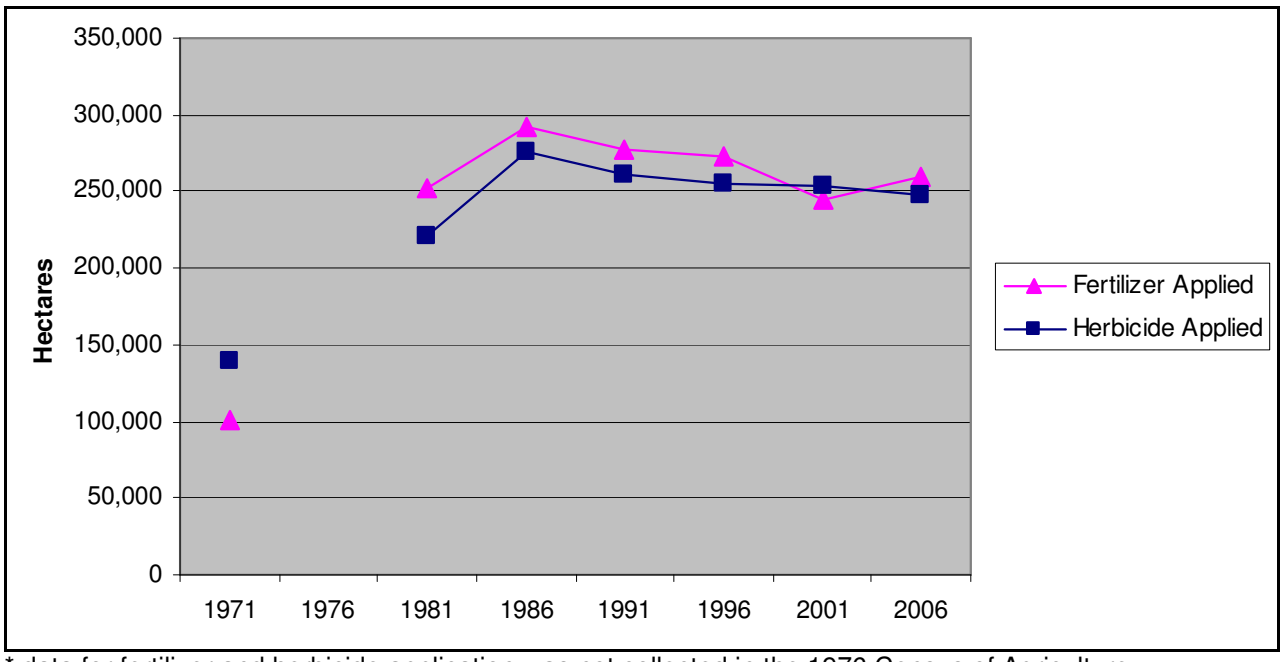
Land Management

Fertilizer and Herbicide Usage

The area of land in the watershed that receives commercial fertilizer each year has fluctuated since its low in 1971 of about 101,000 ha to a high of about 293,000 ha in 1986 (Figure 23). With the exception of an increase from 2001 to 2006, there has been a steady decline since this peak, with about 259,000 ha of land receiving commercial fertilizer in 2006.

Herbicide usage has shown similar trends to fertilizer usage. Land with herbicide applied increased dramatically from 1971 (about 140,000 ha) to its peak in 1986 (about 276,000 ha), then declined to 2006 with about 248,000 ha receiving herbicides that year.

Figure 23 - Trend of fertilizer and herbicide use in the Pembina River Watershed from 1971 to 2006 *

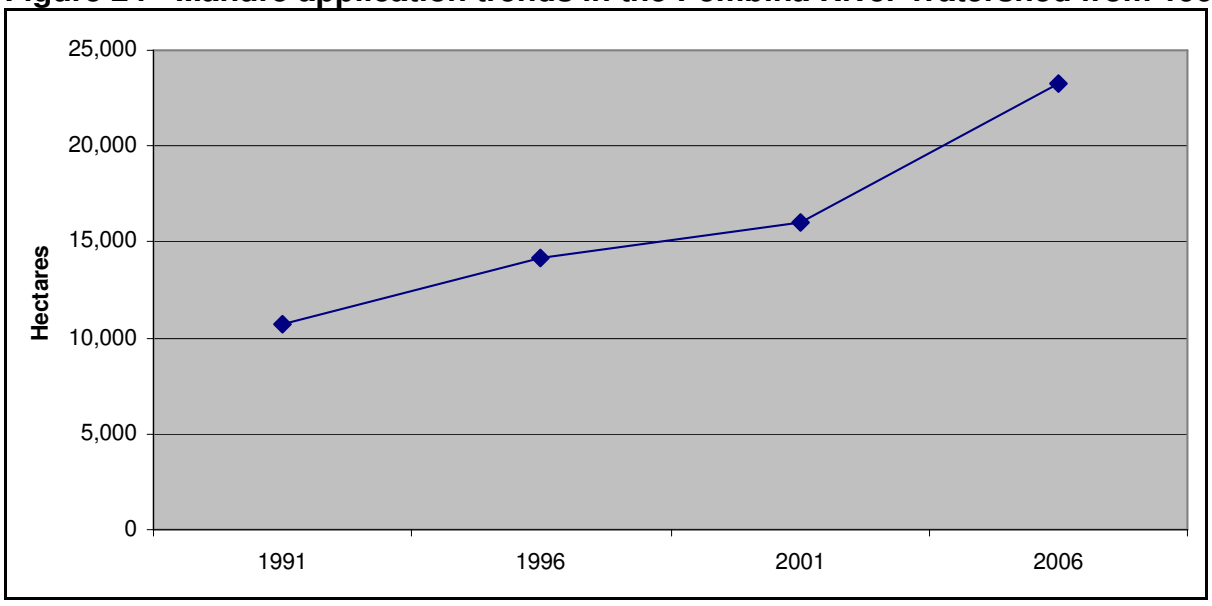


* data for fertilizer and herbicide application was not collected in the 1976 Census of Agriculture

Manure application

The amount of land in the watershed with manure applied has increased every census year since the data was recorded, up from 10,800 ha in 1991 to about 23,300 ha in 2006 (refer to Figure 24). This increasing trend corresponds well with the significant increases in the numbers of pigs in the watershed.

Figure 24 - Manure application trends in the Pembina River Watershed from 1991 to 2006

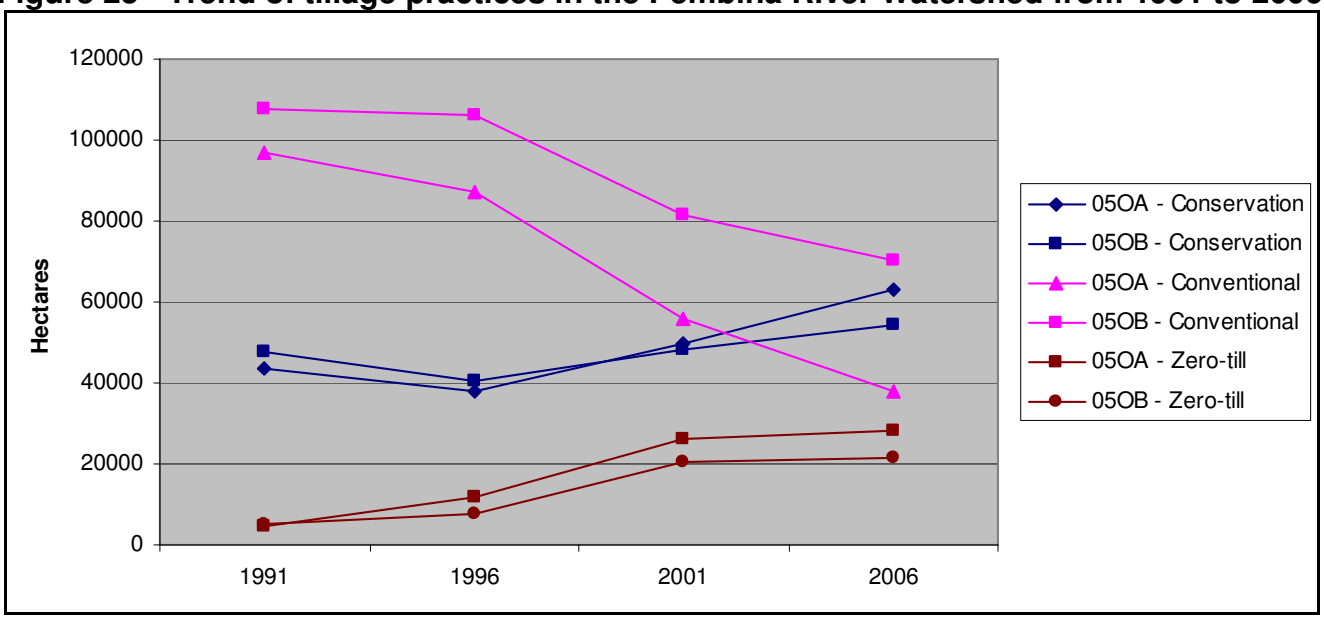


Tillage practices

The type of tillage practices used in the watershed since 1991 shows some definite trends (Figure 25). While the amount of conventional tillage, in terms of the area of land where it is used, has been in steady decline, conservation and zero tillage practices have increased. The amount of conventional tillage practiced experienced an almost 50% reduction from about 205,000 ha in 1991 to 108,000 in 2006, this

was especially true in the Upper Pembina subwatershed (05OA) where conventional tillage was practiced on only about 38,000 ha in 2006 compared to about 97,000 in 1991. The amount of conservation and zero tillage increased from about 101,000 ha in 1991 to about 167,000 ha in 2006. Again, these trends are more evident in the Upper Pembina subwatershed. During the 1991 to 2006 period, the amount of land with zero tillage in Upper Pembina subwatershed increased by 509% (from about 4,600 ha to about 28,300 ha) while conservation tillage increased by about 45% (from about 43,500 ha to about 63,100 ha). During the same time frame, conventional tillage dropped in the Upper Pembina by about 61% (from about 97,000 ha to about 37,700 ha).

Figure 25 - Trend of tillage practices in the Pembina River Watershed from 1991 to 2006



Financial Characteristics

The financial picture for the agriculture sector as captured in the census of agriculture shows some trends since 1971. The amount of capital in the sector has increased dramatically from about $140,000,000 in 1971 to about $1,069,000 in 2006, and with the exception of small declines in 1986 and 1991 the increase has been steady (Figure 26). An examination of farm sales and expenses from 1981 to 2006 shows that while sales have seen modest increases, expenses have increased more leading to lessened profits in the sector (Figure 27). Total profit in 1981 amounted to approximately $50M declining to approximately $31M in 2006, a 38% decrease. With the large decrease in farms over the same period, the amount of profit per farm has changed only slightly from approximately $32,600 per farm in 1981 to approximately $30,500 per farm, or approximately a 6% decrease.

Figure 26 - Total farm capital trends in the Pembina River Watershed from 1971 to 2006

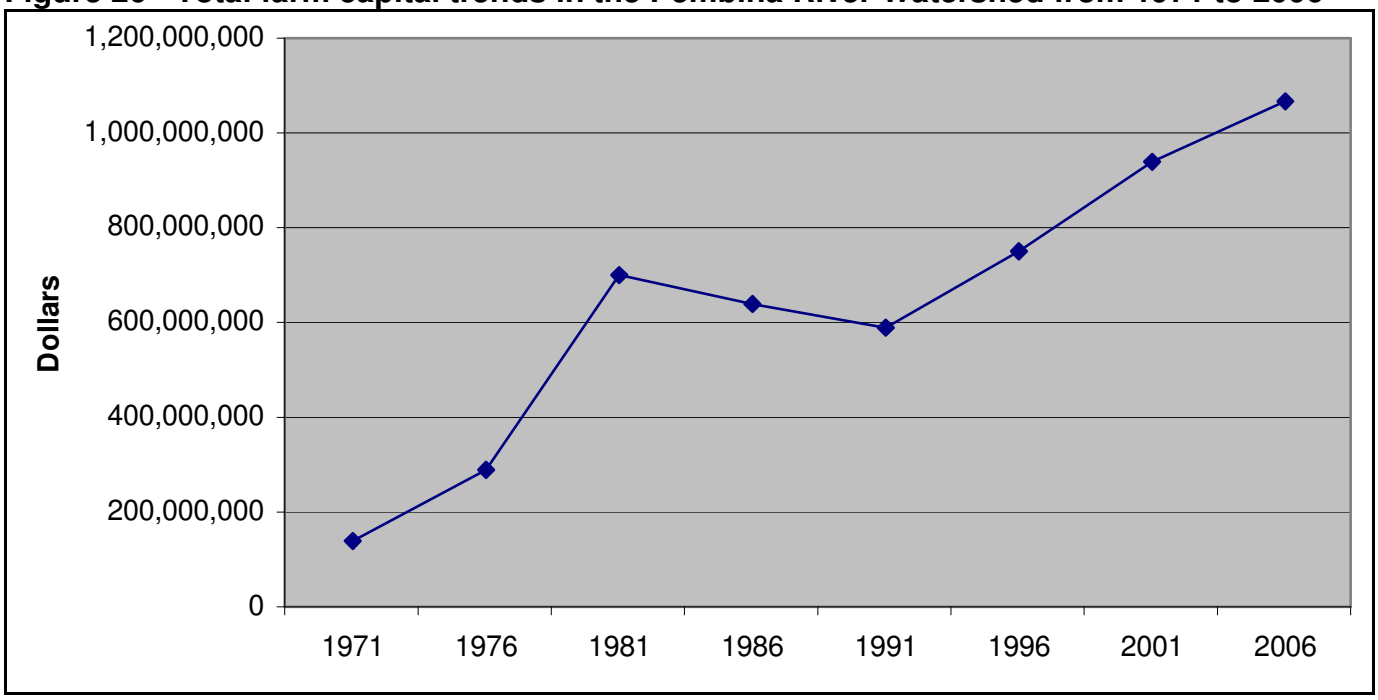
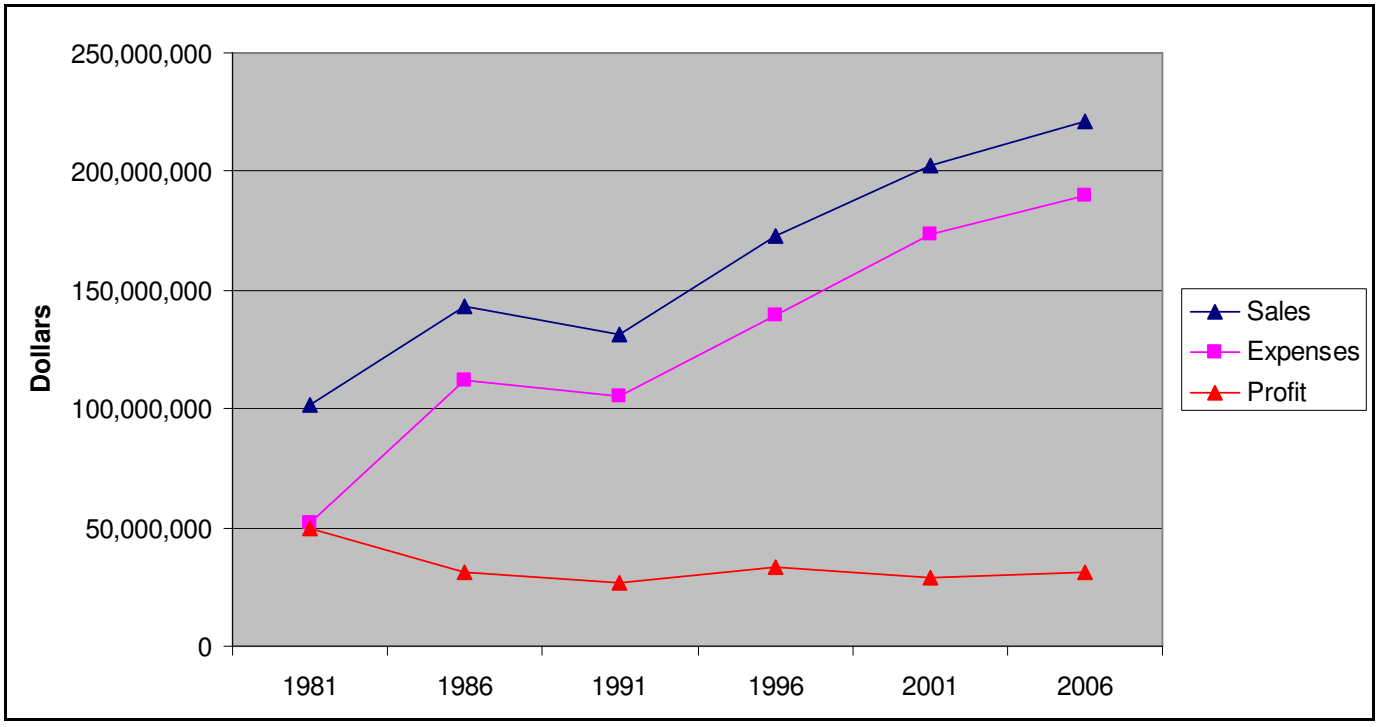


Figure 27 - Farm financial characteristics in the Pembina River Watershed from 1981 to 2006



F. Agricultural Land Use and Management Considerations

This section involves the analysis of a combination of factors, land use and the characteristics of the local landscape, in order to determine where consideration should be given to how the land is used or managed including the potential for adoption of BMPs. Land cover data represents an indicator of how the land is being used, while relevant landscape characteristics and risk factors are contained within the soils dataset. Further information about land cover data can be found in Appendix D, while more information about the soils data can be found in Appendix E.

i. Agricultural Capability Analysis

The Canada Land Inventory System (CLI) was used to classify land based on agricultural capability. The CLI is a comprehensive survey of land capability and land use aimed at providing a basis for making land-use planning decisions. Under the CLI, lands are classified according to physical capability for agricultural use (PFRA, 2005).

Agriculture capability can best be described as the ability of the land to support the appropriate type of crops and agriculture management techniques. Not all land can be managed in the same manner with soil types, topography, stoniness, soil moisture deficiency and low fertility and other potential limitations influencing land use and practices. Classes ranging from 1 to 7 have been established with 1 being the highest rated land class with no limitations to annual crop production and 7 being the lowest rated land for agriculture (not suitable for agriculture). Further information about CLI and specific characteristics and limitations associated with individual land classes is provided in Appendix F.

Analytical Methods
Analysis of the land classes with respect to land cover helps to understand the extent of agricultural activity over marginal lands. An examination of annual cropland from the 2006 land cover will provide estimation to the extent of how much annual cropping is occurring on those marginal lands. Such analysis can also provide an indication of where producers are demonstrating good land management practices by utilizing these marginal lands for purposes other than annual crop production. As well, comparisons examining land cover analysis from the 2001 and 1994 data sets provide opportunity to examine how much change has occurred in agricultural activity with respect to time.

Within the Pembina River Watershed study area, the majority of the land is classified as Class 1, 2, and 3, covering approximately 78% of the study area (Table 6). Another 20% of the soils are considered Class 4, 5, 6 and 7.

2006 Cropland Class 4 and lower
Approximately 20 % (97,809 ha.) of all lands within the study area are considered Class 4 and lower (including what has been classified as organic soils). Examination of 2006 land cover data indicates that approximately 26,586 ha (or approximately 9%) of annual cropland is located on land rated as Class 4 or lower (Table 6 and Figure 28). This means that approximately 71, 385 hectares are being used for other land use practices. The amount of marginal land being annually cropped has shown a slight decrease since 2002 (9.3 %) and 1994 (10.4%)

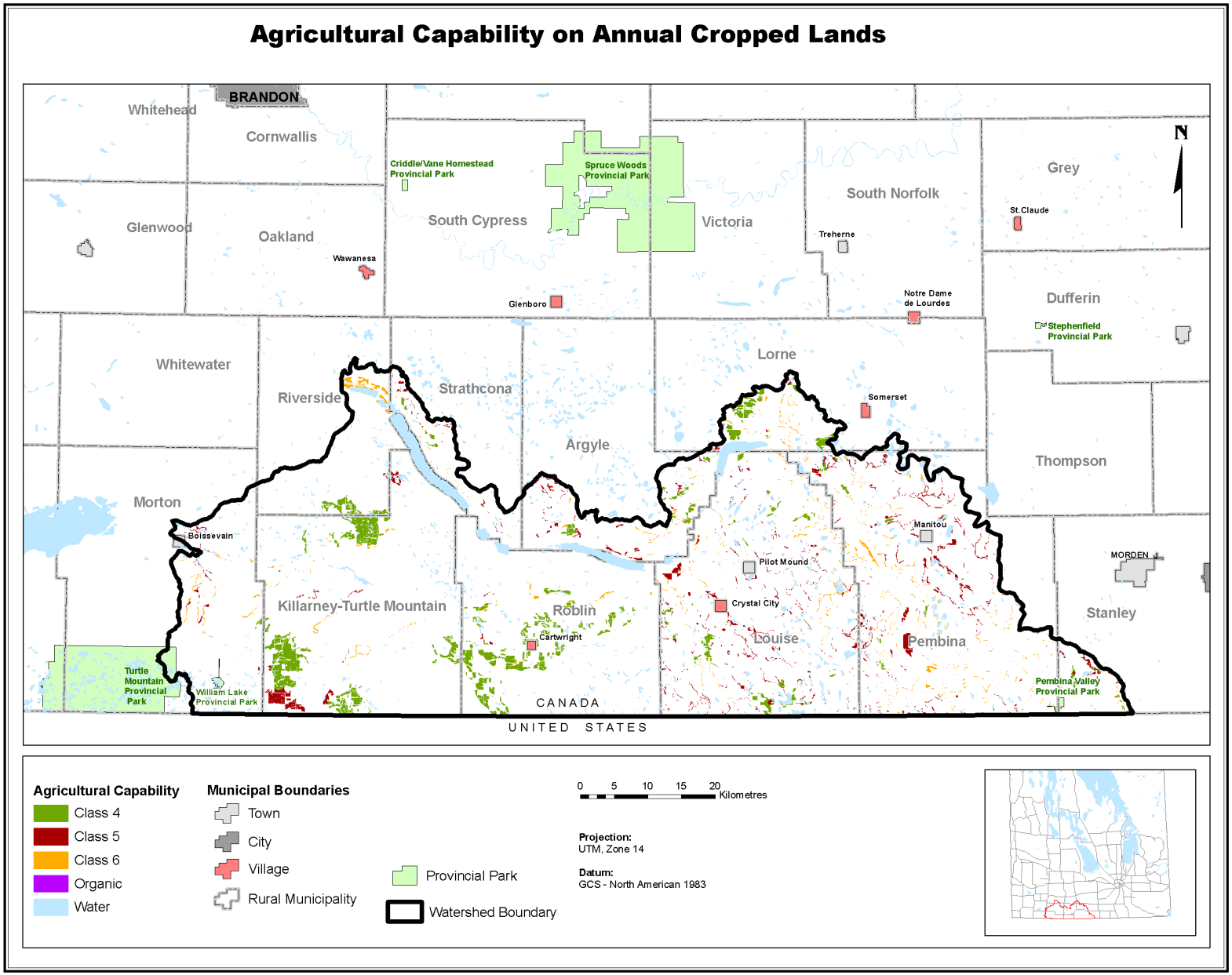
From the 1994 land cover analysis, it was noted that annual cropland had decreased by 12% (36,118 ha), due to land conversions such as grasslands and forages as noted in the earlier in this document. The most significant changes occurred in the Class 2, 3, and 4 soils, where 30,981 ha changed from annual cropland to another land cover category.

Table 6 - Agricultural Capability in the Pembina River Watershed Study Area [1]

Class	Area of Entire Watershed (ha)	2006 Land Cover (Annual Cropland) Area (ha)	Distribution of Annual Cropland[2]	1994 Land Cover (Annual Cropland) Area (ha)[2]	Change from 1994 Land Cover (Annual Cropland) Area (ha & %) [3]
Class 1	39,217	31,197	11%	33,852	-2,655
Class 2	235,773	161,350	57%	179,630	-18,280 (-1%)
Class 3	106,388	64,217	23%	72,709	-8,492
Class 4	30,351	13,911	5%	18,120	-4,209 (1%)
Class 5	21,926	7,401	3%	8,438	-1,037
Class 6	36,011	4,157	1%	5,324	-1,167 (1%)
Class 7	9,388	1,108	-	1,330	-222
Organic	134	10	-	20	-10
Unclassified	436	28	-	34	-6
Water	8,335	99	0%	139	-40
TOTAL	**487,958**	**283,478**	**100%**	**319,596**	**-36,118**

1. Agricultural Capability is based on the CLI Rating of the dominant soil series for each soil polygon
2. Annual Cropland taken from the 2006 Land Cover (from Landsat Imagery)
3. Figure derived from the difference of Land Cover Data - Annual Cropland in Study Area (2006) minus Annual Cropland in Study Area (1994) in each Soil Class

Figure 28 –Areas annually cropped in 2006 on soils with an agricultural capability of Class 4, 5, 6, 7 and organic soils in the Pembina River Watershed Study Area



ii. Environmentally Sensitive Land Analysis

Although there are definitely other changes besides conversion to annual cropping that would lead to the loss of trees and wetlands, such as the conversion to urban or transportation uses, this document focuses on agricultural land use. This section aims at analyzing the conversion of land for annual cropping practices. According to the Census of Agriculture, the amount of land in the watershed being used for annual cropping has been declining since its peak of 322,787 ha or 66% of the watershed area since 1986. However, the land cover data indicates that certain areas of the watershed have experienced conversion to annual cropping during that period. Correlations between 1994 and 2006 land cover data indicate that 14,974 ha (Table 7) of land in the watershed which was classified as trees, grass/pasture, forage, or wetland in 1994 changed to annual cropland in 2006. This would translate to about 1,248 ha/year of land converted to annual cropping over that period (note that these figures do not take into account any conversions from annual cropland to other uses, so this does not necessarily reflect a net increase in annual cropland, in fact trends indicate a decreasing amount of annual cropland, refer to Section Eii and Fi). Further analysis shows that the majority (61%) of the change of grass/pasture and wetlands to annual cropland occurred in the Upper Pembina subwatershed (05OA). The majority (64%) of the change from trees and forage to annual cropland occurred in the Central Pembina subwatershed (05OB). It should be noted that data classification limitations and the timing of the satellite images can introduce discrepancies into these values and further ground-truthing would be required to verify these findings.

Table 7– Change to Annual Cropland, a comparison of 1994 and 2006 Land Cover

1994 Land Cover Class	Amount Changed to Cropland in 2006 (ha)		
	Upper Pembina (05OA)	Central Pembina (05OB)	Entire Watershed
Trees	853	924	1,777
Water	16	7	23
Grass/Pasture	4,876	3,405	8,281
Wetlands	2,046	1,105	3,151
Forage	439	1,326	1,765
Urban	48	286	335
Total	**8,278**	**7,054**	**15,332**

It is important to note that while conversion to annual cropping can present significant economic opportunities and benefits, it also can increase risks to the environment. For example, the increased use of fertilizers and pesticides associated with annual cropping can lead to increased concentrations of contaminants in water if appropriate management practices are not utilized. Due to the increased likelihood of periods of bare soil, erosion risks are also increased under annual cropping practices. It should be noted that crop rotations, specifically including forages into annual crop rotations, will impact these numbers.

Analysis of Potentially Environmentally Sensitive Areas

This section examines land cover in combination with areas that are considered “prime agricultural lands” with an agricultural capability of 3 or greater. For more information on land cover refer to Appendix D, and for agricultural capability refer to Appendix E for information about soils data and to Appendix F for information about the Canada Land Inventory System for land classification.

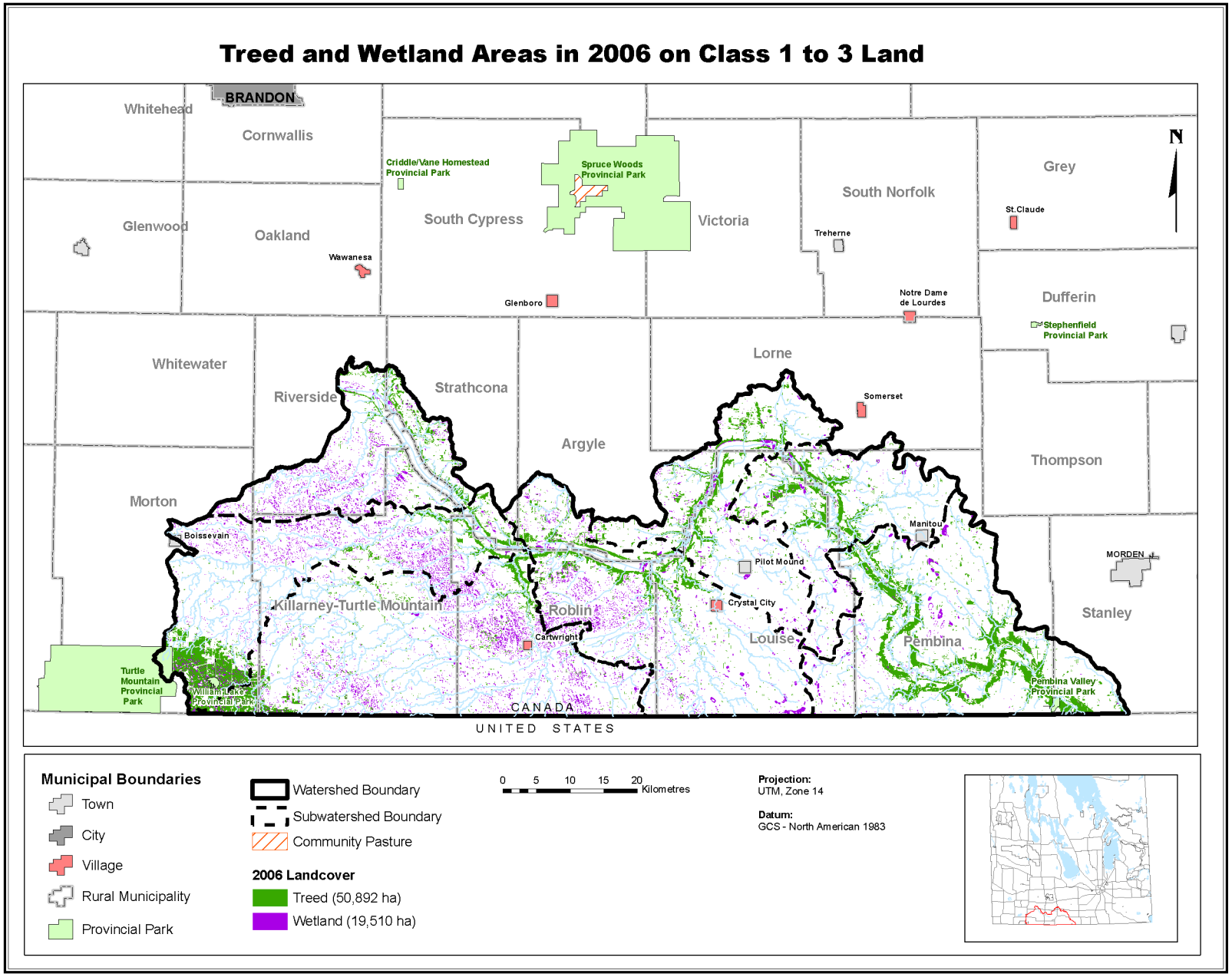
In order to identify vulnerable environmentally sensitive lands that are at risk of conversion to annual cropping, this analysis was narrowed to lands that were classified as forest (tree) or wetland in 2006. Any of these areas that were on land with an agricultural capability class of 1, 2, or 3 were then selected, as these areas present lesser limitations (no limitations, moderate, or moderately severe) for annual

cropping. It is important to note that area of wetland may be underestimated due to that fact that many small wetlands and potholes may not be captured in the data sheets.

Results

This analysis reveals over 70,000 ha of vulnerable sensitive lands. Over 50,000 hectares are dominated by trees, and nearly 20,000 ha are wetlands. Further analysis, shows that many of these are large stands of trees or wetlands of significant size (Figure 29). Nearly 500 contiguous blocks of trees are over 8 ha in size covering about 42,000 ha, and about 280 wetland polygons are greater than 8 ha accounting for almost 4,900 ha. Some ground-truthing of this data would be necessary, but these areas could be used as a proxy for identifying environmentally sensitive or vulnerable lands worthy of protection or special management considerations in an Integrated Watershed Management Plan.

Figure 29 – Forested or wetland areas located on Class 1, 2 and 3 lands as identified in the 2006 Land Cover data



iii. Wind Erosion Risk Analysis

Wind erosion risk information in Manitoba has been developed from the provincial soil survey data and the Soil Landscapes of Canada (SLC Ver 1.0 - See Appendix H). The Wind Erosion Risk model used for the Agriculture Canada Wind Erosion Risk Maps (1989) incorporates soil moisture, surface roughness and aggregate size, and drag velocity by wind. Erosion risk classes were assigned based on the weighted average soil loss for each map polygon. The five classes of soil erosion risk (ranging from negligible to severe) are based on a bare, unprotected soil condition and do not consider land use and crop management factors. Cropping and residue management practices can significantly reduce erosion risk depending on crop rotation, soil type, and landscape features. Basing soil erosion risk on a bare soil scenario helps to identify areas dominated by sensitive, erosive soils which may otherwise be masked if a land use or surface vegetation cover factor was considered (Eilers et. al. 1989).

Approximately 5% of the Pembina River Watershed study area is considered to have a high or severe wind erosion risk (Table 8), primarily in the northwestern portion of the watershed (Figure 30). Affected areas generally correspond to the portions of the study area where fine textured clay over till soils are found Approximately 81% of the watershed is considered low or negligible for soil erosion risk and is generally associated with land under perennial cover, often correlating with Class 4, 5, and 6 soils.

Based on the 2006 land cover data, approximately 5% of the annual cropland is located on soils with a high to severe risk for wind erosion (Table 8). When compared to 1994 land cover, there is a decreasing trend of annual cropland associated with high or severe wind erosion soil types, approximately 3,723 hectares, or about an 8% decrease of the watershed). This decrease was noted in all wind erosion categories, indicating that the changes were probably more attributed to the decrease in annual cropland acres from 1994 to 2006 than due to wind erosion risk factors.

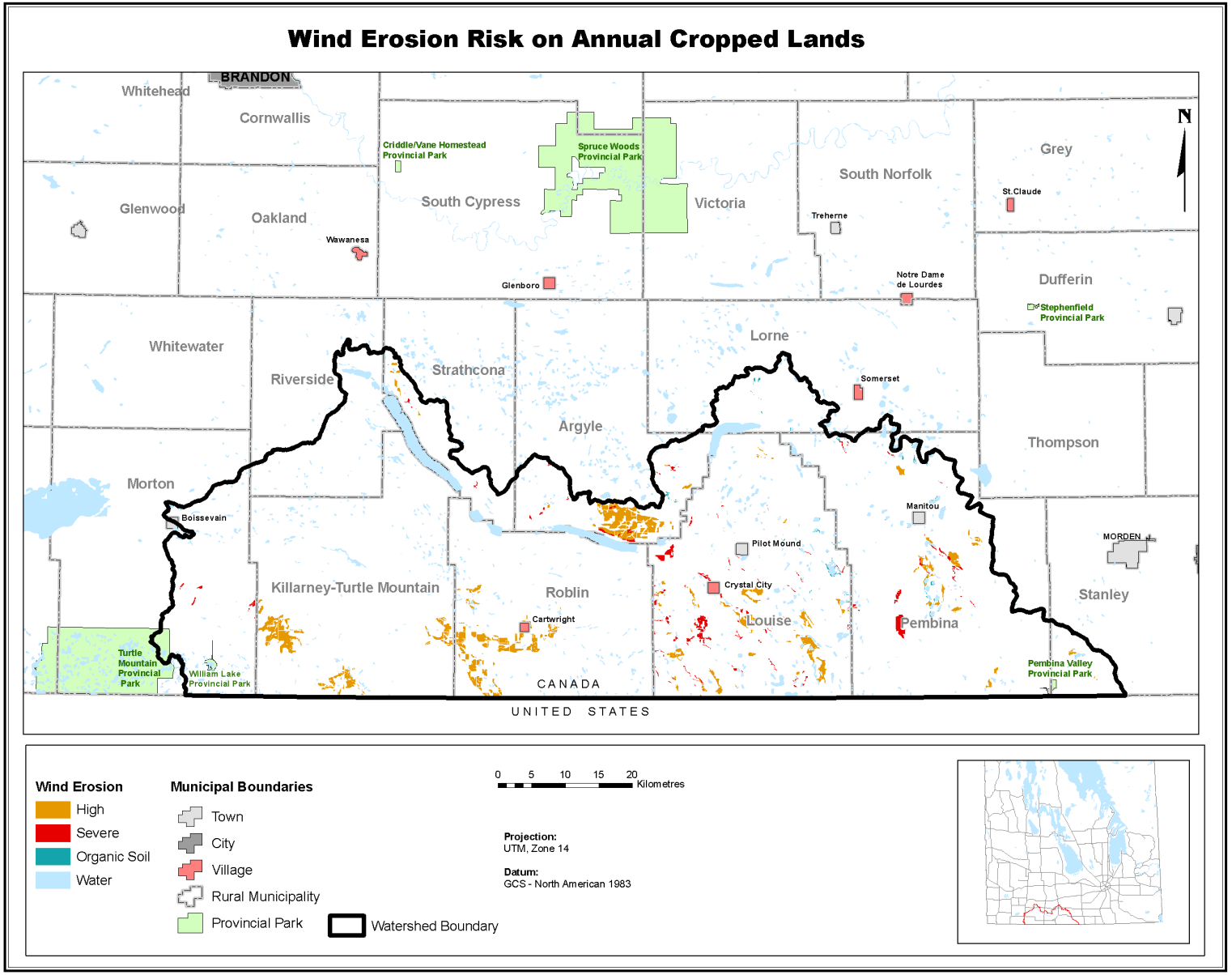
Organic soils, when dry and exposed, are also at risk to wind erosion. The 2006 land cover data indicates that approximately 1% of the annual cropland was located on organic soils.

Table 8 - Wind Erosion Risk on annual cropland in the Pembina River Watershed Study Area from 2006 Landcover [1]

Class	Area (ha)	Percent of Study Area	Distribution of Annual Cropland[2]	1994 Landcover (Annual Cropland) Area (ha)[2]	Change from 1994 Landcover (Annual Cropland) Area (ha &%)[3]
Negligible	375	0%	-	65	-26
Low	397,150	81%	89%	283,741	-29,932 (-1%)
Moderate	15,780	3%	4%	13,098	-1,194
High	20,112	4%	4%	14,415	-3,527 (-8%)
Severe	3,879	1%	1%	2,629	-196
Organic Soil	3,103	1%	-	650	-108
Water	8,383	2%	-	140	-46
Bare Rock		0%	-	-	-
Unclassified	38,995	8%	2%	4,857	-1,063
TOTAL	**487,778**	**100%**	**100%**	**319,596**	**-36,091**

1. Wind Erosion Risk is based on the weighted wind erosion rating for each soil polygon and assumes bare soil.
2. Annual Cropland taken from the 2006 Land Cover (from Landsat Imagery)
3. Figure derived from the difference of Land Cover Data - Annual Cropland in Study Area (2006) minus Annual Cropland in Study Area (1994) in each Soil Class

Figure 30 - Wind Erosion Risk on 2006 Annual Cropland in the Pembina River Watershed[1]



1. Wind Erosion Risk is based on bare soil and does not take into account negative cover on management practices

iv. Water Erosion Risk Analysis

The overland flow of water can, under certain circumstances, carry particles of soil with it. Rain splash erosion, sheet erosion, rill erosion and gully erosion are all caused by water. Where this occurs, there is the potential to carry large quantities of sediment and contaminants to nearby waterways and waterbodies throughout the watershed. This section examines where in the watershed that there may be a greater potential for this to happen.

The analytical component of this section focuses on annual cropland from land cover data (see Appendix D) in conjunction with water erosion risk (see Appendix H) and the proximity of these areas to water courses.

Water Erosion Risk

The risk of water erosion was estimated using the Universal Soil Loss Equation (USLE) developed by Wischmeier and Smith (1965). The USLE predicted soil loss (tonnes/hectare/year) was calculated for each soil component in the soil map polygon. Water erosion risk factors used in the calculation include mean annual rainfall, slope length, slope gradient, vegetation cover, management practices, and soil erodability (Eilers et. al. 2002). Erosion risk classes were assigned based on the weighted average soil loss for each map polygon. The five classes of soil erosion risk (ranging from negligible to severe) are based on bare and unprotected soil conditions. See Appendix G for more information about Water Erosion Risk. Cropping and residue management practices can significantly reduce this risk depending on crop rotation, soil type, and landscape features. Basing the soil erosion risk on a bare soil scenario helps to identify areas dominated by sensitive, erosive soils which may otherwise be masked if a land use or surface vegetation cover factor was considered (Eilers et. al. 2002).

Analytical Methods

In order to focus on areas that may have significant potential to contribute sediments and nutrients to water courses, this section examines three factors. They are (a) land cover, specifically whether the land was in annual crop which significantly increases the likelihood of bare soil conditions and high nutrient application rates, (b) water erosion risk, which takes into account important factors such as slope and slope length, rainfall, and soil erodability, and (c) proximity to water courses where these other factors considered that would likely increase the probability of sediment and nutrients reaching surface waters.

A 50 m buffer was chosen for this particular analysis (note that subsequent analysis could be undertaken with a buffer of a different size) and applied to all designated drains in the watershed. All polygons classified as annual crop in 2006 and as either at a high or severe risk of water erosion that intersected the buffer were selected. Affected areas are highlighted in the map below along with any adjacent cropland from 2006 (Figure 31).

The analysis does not take into account land adjacent to lakes and wetlands, but does include streams and rivers of all sizes and intermittent or permanent. Forage land was not selected but could be considered in future analyses, as it is part of annual crop rotations in some areas. This analysis did not consider other factors that can contribute to bare soil and nutrient transport such as tillage practices or livestock grazing and wintering in riparian areas and along streambanks.

Results

This analysis revealed significant areas of multiple risk factors for water erosion and sediment transport to waterways. Over 1,100 ha of land met the criteria of annual cropland located within 50 m of a waterway with a high or severe risk of water erosion. This accounts for about 4% of the area that is within 50m of a watercourse within the Pembina River Watershed. It should also be noted that the cropland polygons adjacent to these areas totaled over 87,000 ha and the importance of tillage practices, crop rotation, and nutrient management on these lands is also significant as there is a likelihood that runoff from these fields could enter nearby streams and rivers.

Although this analysis identifies areas in the watershed that may be worthy of consideration for future action or mitigation such as BMP promotion or implementation, it is important to note that limitations in the datasets used dictate that ground truthing of these sites is required. Data limitations include the scale of the soils data in some areas of the watershed (see Appendix E), spatial accuracy of watercourses in the map, and the limitations associated with land cover to identify land use. Land cover data is never completely accurate and land use is dynamic and changes may have occurred since the 2006 data was collected. It is important to further investigate whether specific sites are actually at high risk to water erosion to verify if it correlates with the results derived from the soils data (greatly dependant on amount of overland flow, soil type, topography, and vegetation cover). Although there are data limitations, this methodology can potentially be considered as an approach to identifying sites where BMPs could have a significant positive impact in the watershed to reduce water erosion.

Table 9 – Annual cropland located within 50 metres of a provincially designated drain that has a high to severe risk of water erosion by subwatershed

Watershed	Buffer (within 50m of a watercourse) area (ha)	Area of buffer in annual cropland in 2006 with high or severe risk of water erosion (ha)	Percent of buffer in annual cropland in 2006 with high or severe risk of water erosion
Pelican	6,560	241	3.7%
Badger	6,841	425	6.2%
Rock-Swan	6,077	142	2.3%
Snowflake	8,319	319	3.8%
Entire Pembina	**27,797**	**1,127**	**4.1%**

v. Soil Drainage Analysis

Soil drainage reflects the actual moisture content in excess of field capacity and the length of the saturation period within the plant root zone. Excess water content in the soil limits the free movement of oxygen and decreases the efficacy of nutrient uptake. Delays in spring tillage and planting are more likely to occur in depressional or imperfectly to poorly drained areas of individual fields. Surface drainage improvements and tile drainage are management practices that can potentially be used to manage excess moisture conditions in soils but should only be used if deemed appropriate for a site specific situation and only where regulations requirements can be met. Agriculture and Agri-Food Canada (AAFC) has classified soils for their drainage capacity using a five class system (see Appendix I).

Approximately 19% (88,867 ha) of the landbase within the study area can be considered poor to imperfectly drained. These types of lands make up less than 17% (47,117 ha) of annual crop production in the overall watershed, but a significant amount (53%) of the imperfectly drained to poorer soil drainage classes are under annual crop production (refer to Table 10). Most of the imperfectly drained and poorer soils are associated with the south-southeastern portion of the watershed in the Rural Municpalities of Louise and Pembina (refer to Figure 31).

Changes in Land Cover from 1994 to 2006 have shown that the amount of acres in annual cropland have decreased in the more poorly drained classes. There have also been general increases noted in the grassland/pasture and forage land cover in well drained soils. These noted changes are consistent to what has been noted with land cover in general.

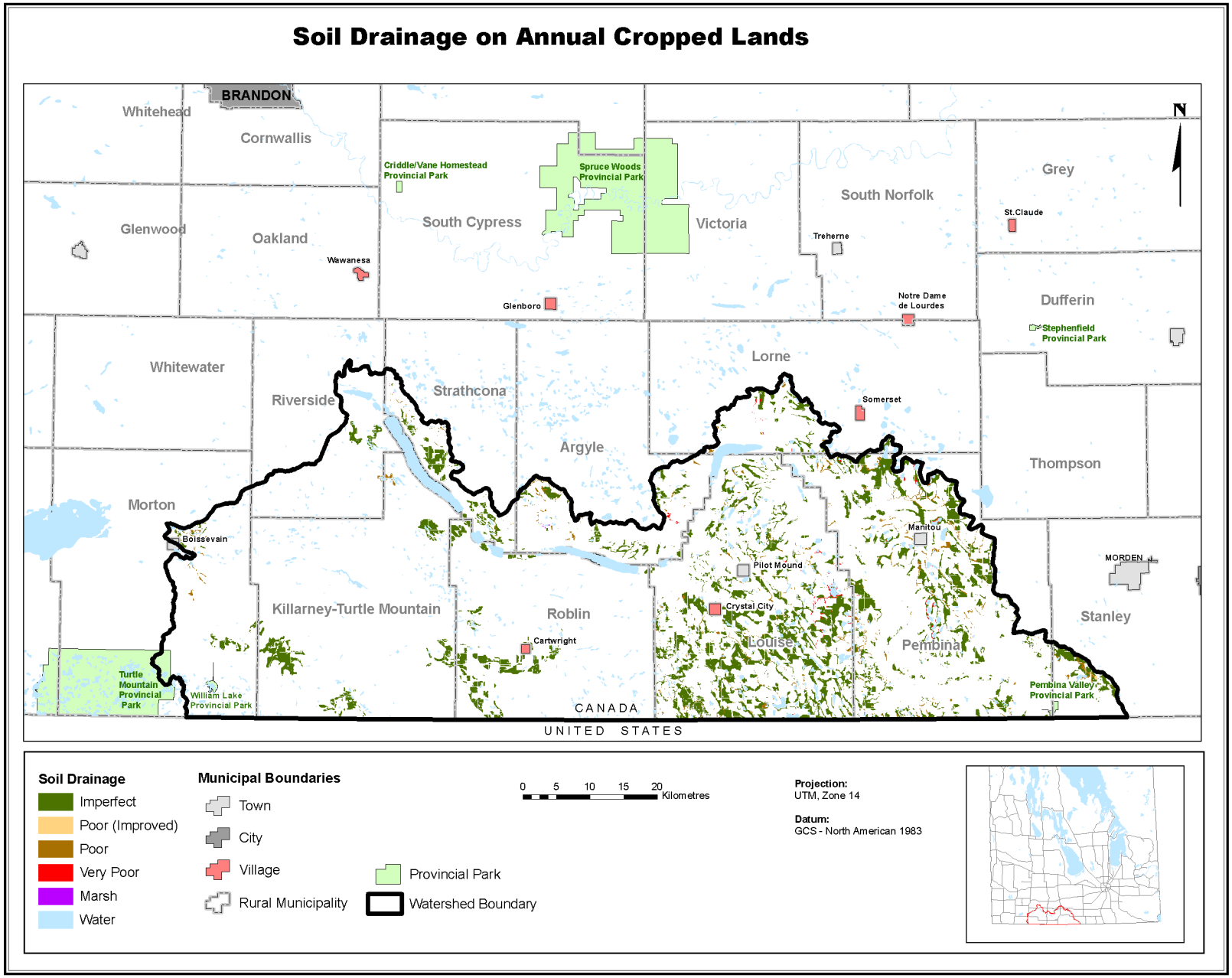
Improved drainage indicates areas where networks of surface drains accelerate surface runoff and reduce the duration of surface ponding. While these drains effectively move water off fields and decrease the amount of standing water in agricultural fields, other adverse effects need to be considered. The drains facilitate water moving off fields more quickly than under natural run off conditions resulting in river channels being filled to high water levels during heavy precipitation events. High water levels could lead to a flood or near-flood stage, thereby increasing the risk for water erosion or property damage. Also, man-made drainage systems tend not to have riparian buffers associated with them, unlike natural and undisturbed watercourses. With decreased or non-existing riparian buffers, there is an increased risk of nutrient and sediment loading into watercourses. Riparian areas and perennial vegetation on adjacent lands are able to trap and store sediment and nutrients from field runoff during the growing season, reducing the risk of contaminating surface water.

Table 10 - Soil Drainage Classes in the Pembina River Watershed [1]

Drainage Class	Area (ha)	Percent of Study Area	Distribution of Annual Cropland[2]
Rapid	41,536	9	2
Well	347,768	71	82
Imperfect	72,402	15	15
Poor (Improved)[3]	48	-	0
Poor	12,809	3	1
Very Poor	3,653	1	0
Unclassified	436	-	-
Marsh	970	-	0
Water	8,335	2	0
TOTAL	**487,958**	**100%**	**100%**

1. Soil Drainage is based on the dominant soil series for each soil polygon
2. Annual Cropland taken from the 2005 Land Cover (from Landsat Imagery)
3. Poor (Improved) represents soils that were considered poorly drained soils that have been improved with drainage.

Figure 31 - Soil Drainage with Respect to 2006 Annual Cropping in the Pembina River Watershed Study Area



G. Recent Federal and Provincial Policies and Programs Affecting Agricultural Land Use and Management

i. Agriculture and Land Use Planning Policies

Integrated watershed planning is a community based focused planning process around issues like water quality. This planning process needs to also support the existing community framework for economic development and land use planning. In most cases, this means, integration of the IWMP into the existing Development Plan. The Development Plan is the local legal framework based on the Provincial Land Use Policies. It is the role of MAFRI's Land Use and Policy division to provide agricultural input into land development plans and proposals based on soil resource information, and in relation to traditional and potential agricultural land uses.

In the Pembina River Watershed, there are eight planning districts, each with their own development plan. These are;

- Killarney Area Planning District
- Pelican – Rock Lake District Planning Scheme (1971) / 23 West Planning District Draft (Pelican – Rock Lake Draft)
- The Louise Planning District
- South Central Planning District
- Roblin – Cartwright Planning District
- Morden Stanley Thompson Winkler Planning District
- Morton Boissevain Planning District
- Pembina Manitou Planning District

All of these planning districts/municipalities have Development Plans which govern land use decisions including the protection and use of agricultural lands. Development of rural lands for non-agricultural use can impact watershed health, and may result in enhanced drainage beyond agricultural requirements. Because of this, the ability of the watershed to provide ecological goods and services such as the retention and filtering of water can be affected when agricultural land is subdivided or taken out of agricultural production.

Within a Development Plan, protecting agricultural land from non-agricultural use may also mean protecting wetlands and tree cover, especially if the farmland is maintained for grazing purposes. Having agricultural lands protected in a Development Plan benefits the five issues (flooding, drinking water quality, surface water quality, soil/erosion loss, and drainage) identified within the Pembina River Basin Watershed Management Plan.

The following sections describe the framework for land use planning from a legal perspective, set out by the Provincial Government.

Provincial Land Use Policies (PLUPs): These policies guide local and provincial authorities in preparing Development Plans and in making land use decisions. The PLUPS cover nine broad policy areas, of which agriculture is one component. The other areas are General Development, Renewable Resources, Water and Shoreline, Recreational Resources, Natural Features and Heritage Resources, Flooding and Erosion, Provincial Highways, and Mineral Resources. The various government departments "own" their policies and are involved in establishing them.

Development Plans: The Development Plan is the agreement between the local and provincial governments on matters concerning land use. Once in place, all proposed development and land use changes must be evaluated under the policies of the development plan. This is where the policies governing the protection of prime agricultural land and agricultural operations are set out.

The Provincial Land Use Policies are applied at the local level through the Development Plans, initiated by a municipality or planning district (group of municipalities). The purpose is to set out land use objectives and patterns or characteristics of development for an area. Through the Development Plan, lands are designated for certain uses such as agriculture, agriculture restricted, residential, industrial or commercial.

Zoning By-Laws – Regulating the Use of the Land: Following the approval of a development plan, a municipality must enact a zoning by-law that is consistent with their development plan. A municipal zoning by-law contains the rules and regulations that control development as it occurs. A zoning by-law further divides a municipality into various zones such as rural residential, highway-commercial and general agricultural. For example, an area that is designated as Agricultural in a development plan may be further zoned as Agricultural General and Agricultural Restricted, with both zones having separate criteria for agricultural development. The zoning by-law sets out requirements and criteria under which development may occur, including property site size, dimensions, separation distances and other siting criteria. It also specifies permitted and conditional uses within each zone.

Zoning by-laws can influence the consumption of agricultural land by the types of development it will permit within the agricultural areas. Generally, only resource-related and agriculturally related developments should be permitted in agricultural areas.

As a **Permitted Use,** a development has the basic right to be established but a development permit must be issued. **Conditional Uses** are certain types of development (e.g. livestock operations), which due to their inherent characteristics may have potential adverse impacts on nearby properties and resources and therefore have to undergo a special process of review and approval, including a public hearing.

PLUPS Agriculture Policy: The Provincial Land Use Policies outline Agriculture's interests to protect land that is used for agriculture by minimizing the subdivision and wasteful use of this land and protecting farms from encroachment and disturbance by other uses which may be incompatible with normal farming operations. These interests are addressed in the PLUPs Policy #1- General Development, Policy #2 – Agriculture and Subdivision Policies sections of the Provincial Land Use Polices Regulation.

With respect to Policy #2, the objectives of the Agriculture Policy are to maintain a viable base of agricultural lands for present and future food production and agricultural diversification, and to protect economically viable agricultural operations from encroachment by other land uses which could adversely affect their sustainability.

Soils and Provincial Land Use Planning: It is important to recognize that for planning purposes, the determination of the classification of the agricultural capability of an area is based on the capability class of 60% or greater of the quarter section or river lot. If 60% or greater of a river lot or quarter section is Class 3 or better for agricultural capability, then the entire river lot or quarter section is considered to be prime agricultural land from a planning perspective. For example, MAFRI often reviews subdivision applications in designated agricultural areas for 5-10 acre lots for residential purposes. Although the 5 acre site itself may have an agricultural capability rating of CLI Class 4 or poorer, the remaining quarter section may be considered prime agricultural land by definition in the Provincial Land Use Policies. In this scenario where the majority of the quarter section is prime agricultural land and the surrounding area is actively farmed, MAFRI would not recommend approval of the subdivision.

One non-farm dwelling in an agricultural area can also have a shadow effect that covers a much larger area than the 5 acre lot that it is located on. The potential for land use conflicts increases as the number and the density of non-farm dwellings increase.

For local government planning purposes, MAFRI supports only the use of detailed soil survey information (at a scale of 1:50,000 or better) in making site specific decisions pertaining to land use. Reconnaissance scale information published by Manitoba Soil Survey and the Canada Land Inventory Maps as published by the Government of Canada may be used in the development plan as a reference, but should never be used for a site specific land use decision. Prime Agricultural Land and Viable Lower Class land are of key concern related to agriculture when it comes to more localized planning activities.

Prime Agricultural Lands: Land composed of mineral soil determined by Manitoba Agriculture to be of dryland Agricultural Capability Class 1, 2 or 3 and includes a land unit of one quarter section or more or a river lot, 60% or more of which is comprised of land of dryland Agricultural Capability Class 1, 2, or 3.

Viable Lower Class Land – Land that is not prime agricultural land but that is used for agriculture or has the potential to be used for agriculture. It is defined in the Provincial Land Use Policies Regulation 184/94 as "land other than prime agricultural land on which agricultural activities that contribute to the local economic base are the dominant land use". Lower class agricultural lands (i.e. Class 4 and 5) are well suited for expanding forage production and pastureland to support the Province's beef industry.

Some municipalities, particularly those municipalities with smaller areas of prime agricultural land, have included policies to protect land that is Class 4. Careful planning for the use of this lower rated land in an agricultural area provides for maximum agricultural diversification opportunities. It should be noted that protection of Viable Lower class soil often protects areas of biodiversity on the landscape.

Some of the Planning Districts across the province have started to integrate the Nutrient Management Regulations administered by Manitoba Water Stewardship, into their development plans. Whether or not these regulations are included, they apply to all lands across Manitoba. (Appendix K).

It is recommended that new livestock operations should not be permitted on soils determined by detailed soil survey (scale of 1:50,000 or better) to have an agricultural capability of Class 6, 7 or on unimproved organic soils as described under the Canada Land Inventory.

It is important to note that livestock operations for this purpose are defined as "a permanent or semi-permanent facility or non-grazing area, including all associated manure collection facilities, where at least 10 animal units of livestock are kept or raised"**.** Therefore, this does not include enclosed grazing areas and use of Class 6 and 7 soils used for pasture is still permissable. This reflects new regulations for manure application and residual nitrate nitrogen levels that are permissible based on the agricultural capability class and subclass of the soil under the Livestock Manure Management and Mortalities Regulation under the Environment Act administered by Manitoba Conservation (Appendix L).

Municipalities are encouraged to use the agricultural capability maps as a support tool when making planning decision related to livestock development.

Livestock Operations Policy (LOP): In 2000, the Manitoba Government announced its Livestock Stewardship Initiative with the aim to ensuring the sustainable development of Manitoba's livestock industry. Following consultations with public, municipalities, environmental groups and industry, the government announced changes to *The Planning Act* and other legislation with respect to livestock operations. This included the following:

- Mandatory adoption of a development plan by Jan. 1, 2008 with a livestock operation policy
- All livestock operations of a size of 300 animal units (AUs) or greater are a conditional use and require a Technical Review (3 km notification)
- Specifies the types of conditions that may be imposed on the approval of a livestock operation

- Development agreements can involve timing of construction, control of traffic, and construction or maintenance of roads or landscaping required to service the livestock operation
- Municipalities or planning districts must designate areas in the development plan where expansion or development of livestock operations: may be allowed; may be allowed up to a specified maximum size; and/or, will not be allowed
- A Development Plan should state the general separation distances for livestock operations with reference to the minimums

These guidelines provide for a more proactive planning process for livestock as part of the development plan process, more certainty in terms of how livestock operations (LO's) will be handled in the municipality – and reduced conflict at the conditional use stage. Municipalities continue to make final decisions on where LO's are permitted in their municipality.

Note: NO conditions may be set regarding the storage, handling, application or transportation of manure, other than requiring a cover.

Additional Considerations from an Agricultural Perspective

The Nature of the Surrounding Area: If the surrounding area is predominantly agricultural and is generally maintained in large parcels, the conversion of farmland to non-farm uses can influence the commercial viability of farms in the following ways:

- Loss of farmland and presence of non-farm development may reduce a farmer's ability to respond and adapt to changing economic and market conditions and ultimately manage their business.
- Increased rural residential development in agricultural areas generally tends to increase land assessment values and property taxes.
- Increased non-farm uses in agricultural areas increases land use conflicts (crop spraying, dust, odours).

Proximity of Livestock Operations: The creation of a rural residential lot may impose a minimum separation distance, which may restrict the expansion of existing livestock operations and the establishment of any new operations.

Municipal zoning by-laws set separation distances between livestock operations and residential development. It is recommended that municipalities use the minimum separation distances from livestock operations to non-farm land uses (ex. single residence and designated residential and recreational areas). These separation distances are based on odour considerations and are therefore greater for operations using an earthen manure storage facility. The separation distance also increases as the size of the livestock operation increases. It is important to note that the recommended separation distances for siting livestock operations are much greater from designated residential areas than from a single residence. The distances are about four times as great.

Manure Application in the Surrounding Area: Proposed changes to the *Pesticide and Fertilizer Control Act* will bring into regulation recommended setbacks for manure spreading. These distances are determined based on odour considerations and vary with the method of application. Distances are significantly greater for designated residential areas than they are from a single residence.

Development Plans are a key tool for land management at the local level, and are crucial for meeting environmental goals within the economic and social framework of the area. Protection of farm land is important for not only ensuring sustainable agricultural production in the watershed but also in maintaining its environmental and socioeconomic health.

ii. Recent Federal-Provincial Programs

Environmental Farm Planning and Canada-Manitoba Farm Stewardship Program - On-Farm Beneficial Management Practices Adoption

In 2003, the Agricultural Policy Framework (APF) was launched as a new national approach to support agricultural activities associated with Business Risk Management, food safety and quality, science and innovation, environment, and skill development. In support of priorities related to soil, air, water and biodiversity, various environmental initiatives were introduced across Canada including Environmental Farm Planning and the National Farm Stewardship Program. Environmental Farm Planning (EFP) is awareness and planning tool used to enhance producers' understanding of potential on-farm environmental risks and to develop action plans for how these risks can be addressed. Many producers in Manitoba, including those in the watershed, have participated in the EFP process to gain an improved understanding of the potential environmental risks associated with agriculture, as well as, those on their own farms. The EFP process also allowed producers to develop an action plan that outlines how potential risks on their farms can be addressed through the adoption of beneficial management practices (BMPs). Financial and technical support has been offered to producers wishing to adopt BMPs through the Canada Manitoba Farm Stewardship Program (CMFSP) between 2003 and 2009. This program offered 30 different BMPs to producers that had completed an EFP. (For a list and description of the BMPs see Appendix M).

Participation in the Environmental Farm Plan Program is reported by municipalities in and around the study area (See Appendix N). The information portrays the number of participants in the Environmental Farm Planning process based on where EFP workshops were held. Therefore it should be noted that participants may reside in the surrounding area and not necessarily in location of the workshop. Environmental Farm Planning Workshops were well attended, with a high degree of producers completing the process to receive a Statement of Completion for eligibility to BMP funding through the CMFSP. These numbers within the study area were at or above the Manitoba average as well, indicating that producers in the Pembina watershed are proactive in nature and environmental issues are high on their priorities.

In the Pembina River Watershed study area, there were 856 BMP projects that were adopted by producers. All of these BMPs contribute to reducing risks to water quality. Of the 856 adopted, 114 of the BMPs were related to point source protection and 676 were related to protection to non point source pollution. In addition, there were 78 BMPs that provided protection from the non point source pollution related to cropping (Pesticides), and 66 were BMPs (Soil Erosion/Flood Protection, Biodiversity) specific to point source protection that could apply to either a cropping or livestock operation.

Of the 856 BMPs adopted in the IWMP study area, almost 50% were non-point source crop related. There is also a fairly good uptake to non-point source Livestock Related BMPS (169) and point source BMPs that were related to farming operations outside of Livestock (105).

It should also be noted that a majority of the point source and non point source crop related BMPs were implemented in the eastern subwatersheds (Rock-Swan and Snowflake) while more of the livestock related non point source BMPs were completed in the western subwatersheds (Pelican and Badger).

The top three BMPs adopted by producers in the study area through the CMFSP were Improved Cropping Systems, Product and Waste Management, and Winter Site Management which is consistent with trends throughout the rest of Manitoba.

The adoption BMPs by producers is not limited to those funded through the CMFSP. Other agencies like Conservation Districts, Ducks Unlimited Canada, and Manitoba Habitat Heritage Corporation also support the adoption of various BMPs. In addition, as indicated in the public consultation process for the

IWMP, there have been many producers who have adopted BMPs on their own initiative, so it is difficult to determine precise adoption levels. However, the CMFSP program data does suggest that producers in the watershed are among the most progressive in Manitoba in terms of BMP adoption and that future conservation programs that may stem from IWMP implementation are likely to have considerable levels of participation in this region.

Table 11 - BMP Adoption through the Canada-Manitoba Farm Stewardship Program 2003-2008[8] by Subwatershed

BMP Categories	Pelican	Badger	Rock-Swan	Snowflake	Pembina Total
Point Source - Livestock Manure Related[1]	< 5	< 5	< 5	5	9
Point Source - Other (Petroleum, Nutrients from Feed, Pesticides, etc.)[2]	19	22	34	30	105
Non-Point Source - Livestock Related[3]	33	54	48	34	169
Non-Point Source - Crop Related[4]	71	93	151	114	429
Non-Point Source - Crop Related (Pesticides)[5]	11	23	19	25	78
Soil Erosion, Flood Protection[6]	8	15	12	8	43
Biodiversity[7]	< 5	< 5	14	< 5	23
Total	**144**	**212**	**280**	**220**	**856**

(1) These include BMPs 1, 2, 4, 5, 6
(2) These include BMPs 8, 9, 17
(3) These include BMPs 3, 7, 10, 26, 30
(4) These include BMPs 14, 18, 24, 29
(5) These include BMPs 16, 20, 25
(6) These include BMPs 11, 12, 13, 15, 19, 27
(7) These include BMPs 21, 22, 23, 28,
(8) Refer to Appendix M for BMP category and names

H. Agricultural Land Use and Management Recommendations*

* Specific approaches and opportunities related to recommended actions, including potential target areas and indicators, need to be explored further by the Project Management Team. Potential collaboration with partners and stakeholders should be considered

Watershed Issue		Analysis	Recommended Actions*	Target Areas*	Potential Indicators*
Drinking Water Quality	**Public**	**Annual cropping of marginal lands**, class 4 and lower can present a significant risk of soil erosion and nutrient transfer to surface waters. The following findings from this document refer to this issue: • Cropland dominates the watershed (2006 Land Cover suggests 58%) **(Section Ei)** • About 26,000 ha or about 9% of land in the watershed was in annual crop in 2006 and Class 4 or lower **(Section Fi)** • Producers have made significant advances in land management in recent years to address soil erosion, with an almost 50% reduction in the amount of conventional tillage practiced since 1991. This trend is more evident in the upper Pembina watershed where producers are cropping significant amounts of Class 4 land. There has also been a steady increase in the amount of perennial cover in the watershed (e.g. improved pasture and alfalfa) since 1986 **(Section Eii)**	**Marginal Land Management** - Promote appropriate management considerations and support the adoption of sustainable beneficial management practices where annual cropland is located on soils with agricultural capabilities of Class 4 and, poorer, as well as organic soils in source watersheds	Areas within **drinking source watersheds**, specifically those that are: • In the Upper Pembina watershed • Annual cropped lands of class 4 and lower	• Source water quality results • Proportion of drinking source watersheds that: ▪ Are Cropland of class 4 or lower ▪ Have BMPs implemented on cropland of class 4 or lower including tillage practices
		Changing use and management of environmentally sensitive lands, such as natural forests and wetlands that provide valuable ecological services like clean water. The following findings from this document refer to this issue: • About 15,000 ha of land in the watershed that was classified as trees, grassland/pasture or wetland in 1994 was changed to annual cropland in 2006 **(Section Fii)** • Based on analysis described in section Fii, about 70,000 ha of land in the watershed could be considered vulnerable or environmentally sensitive **(Section Fii)** • Producers have made significant positive changes on the landscape with respect to sensitive lands, there has been a steady increase in the amount of perennial cover in the watershed (e.g. improved pasture and alfalfa)) since 1986 **(Section Eii)** • Increased returns from crops could increase demand for cropland, possibly leading to more conversion of marginal lands to annual crop production, that may help alleviate the trends of reduced profits in the agriculture sector **(Section Eii)**	**Management of Environmentally Sensitive Lands -** Promote the protection and special management of lands such as wetlands and forests, and erosion prone lands within source watersheds. Further ground truthing, prioritization and analysis based on Section Fii could be undertaken to increase accuracy in identifying vulnerable or sensitive lands. **Riparian BMPS-** In environmentally sensitive areas that are not in annual cropland, like pastures in riparian areas, grazing management BMPs in should be implemented or promoted.	Areas within **drinking source watersheds**, specifically those that are: • Wetland or perennial cover (forest, grassland or pasture) on class 3 or higher land •	• Source water quality results • Proportion of drinking source watersheds that: ▪ Are forested and wetland areas ▪ Have grazing BMPs implemented in riparian areas
		Water erosion risk on annual cropland near watercourses - soils and land cover data suggest there are areas of the watershed with high risk of water erosion and are in close proximity to water courses, meaning sediment and nutrient transport could be contributing to water quality declines **(see section Fiv)**. Due to data limitations, further attention to these areas such as site assessments would be required to determine if action (BMP implementation) is indeed warranted at that location. The following findings from this document refer to this issue: • Cropland dominates the watershed (2006 Land Cover suggests 58%) **(Section Ei)** • Over 1,100 ha of land are within 50 m of a water course, and were annual cropland in 2006 and of high or severe risk of water erosion **(Section Fiv)** • Producers have made significant advances in land management in recent years to address soil erosion, with an almost 50% reduction in the amount of conventional tillage practiced since 1991. This trend is more evident in the upper Pembina watershed where producers are cropping significant amounts of Class 4 land. There has also been a steady increase in the amount of perennial cover in the watershed (e.g. improved pasture and alfalfa) since 1986 **(Section Eii)** • There has been 43 BMPs that have been adopted in the Pembina River Watershed to mitigate soil erosion/flooding. Approximately 54% (23) of those BMPs subscribed are with the Upper Pembina watershed.	**Water Erosion Mitigation** - Promote BMPs within designated source water areas with high priority water erosion risk areas (e.g. riparian buffer design and establishment assistance programs)	Areas within **drinking source watersheds**, specifically those that are: • At high or severe risk of water erosion, in close proximity to waterways and in annual crop production	• Source water quality results • Proportion of drinking source watersheds that: ▪ Are in high or severe risk of water erosion, in annual cropland, within 50 m of a water course ▪ Have BMPs implemented that are designed to reduce water erosion (e.g. cover crops, buffer strips, reduced tillage, etc.)
		Nutrient transport from agricultural land as a result of increased application of fertilizers and manure. The following findings from this document refer to this issue: • An increase in canola and decline in spring wheat production may be leading to increased levels of nutrient application to cropland **(Section Eii)** • More pigs and cattle in the watershed has lead to more manure being applied to the land **(Section Eii)**	**Nutrient Losses from Agricultural Lands** - Promote BMPs within source watersheds related to reducing nutrient transport to waterbodies (e.g. nutirent management plans, soil testing, manure testing, variable rate application, riparian area management and buffer strips)	Areas within **drinking source watersheds**, specifically those that are: • In annual crop production and receive fertilizer or manure application	• Source water quality results • Proportion of drinking source watersheds that have BMPs implemented that are designed to limit nutrient losses from cropland (e.g. nutrient management plans, buffer strips, soil and manure testing)
	Private	**Private water wells** as the primary drinking source for the majority of farms in the watershed.	**Private Water Source Assessments** - Continued promotion of private source assessments and action plans like those included in the EFP program Well Head Protection BMPS- Continue to provide assistance to producers to upgrade or protect their well	Entire watershed	Number of assessments/plans developed as a percentage of total farms
Surface Water Quality		**Annual cropping of marginal lands**, class 4 and lower can present a significant risk of soil erosion and nutrient transfer to surface waters. The following findings from this document refer to this issue: • Cropland dominates the watershed (2006 Land Cover suggests 58%) **(Section Ei)** • About 26,000 ha or about 9% of land in the watershed was in annual crop in 2006 and Class 4 or lower **(Section Fi)** • Producers have made significant advances in land management practices in recent years to address soil erosion, with an almost 50% reduction in the amount of conventional tillage practiced since 1991. This trend is more evident in the upper Pembina watershed where producers are cropping significant amounts of Class 4 land. There has also been a steady increase in the amount of perennial cover in the watershed (e.g. improved pasture and alfalfa) since 1986 **(Section Eii)**	**Marginal Land Management** - Promote the adoption of sustainable beneficial management practices where annual cropland is located on soils with agricultural capabilities of Class 4 and, poorer, as well as organic soils	Areas in the watershed that are: • In the Upper Pembina watershed • Annual cropped lands of class 4 and lower	Proportion of the watershed that: ▪ Is Cropland of class 4 or lower ▪ Has BMPs implemented on cropland of class 4 or lower

* Specific approaches and opportunities related to recommended actions, including potential target areas and indicators, need to be explored further by the Project Management Team. Potential collaboration with partners and stakeholders should be considered

Watershed Issue	Analysis	Recommended Actions*	Target Areas*	Potential Indicators*
Surface Water Quality (cont.)	**Changing use and management of environmentally sensitive lands**, such as natural forests and wetlands that provide valuable ecological services like clean water. The following findings from this document refer to this issue: • About 15,000 ha of land in the watershed that was classified as trees, grassland/pasture or wetland in 1994 was changed to annual cropland in 2006 **(Section Fii)** • Based on analysis described in section Fii, about 70,000 ha of land in the watershed could be considered vulnerable or environmentally sensitive **(Section Fii)** • Producers have made significant positive changes on the landscape with respect to sensitive lands, there has been a steady increase in the amount of perennial cover in the watershed (e.g. improved pasture and alfalfa)) since 1986 **(Section Eii)** • Increased returns from crops could increase demand for cropland, possibly leading to more conversion of marginal lands to annual crop production, that may help alleviate the trends of reduced profits in the agriculture sector **(Section Eii)**	**Management of Environmentally Sensitive Lands -** Promote the protection and special management of lands such as wetlands and forests, and erosion prone lands. Further ground truthing, prioritization and analysis based on Section Fii could be undertaken to increase accuracy in identifying vulnerable or sensitive lands. **Riparian Management-** In environmentally sensitive areas that are not in annual cropland, like pastures in riparian areas, grazing management BMPs in should be implemented or promoted.	Areas in the watershed that are: • Wetland or perennial cover (forest, grassland or pasture) on class 3 or higher land	Proportion of the watershed that: ▪ Is treed and wetland areas ▪ Has grazing BMPs implemented in riparian areas
	Water erosion risk on annual cropland near watercourses - soils and land cover data suggest there are areas of the watershed with high risk of water erosion and are in close proximity to water courses, meaning sediment and nutrient transport could be contributing to water quality declines **(see section Fiv)**. Due to data limitations, further attention to these areas such as site assessments would be required to determine if action (BMP implementation) is indeed warranted at that location. The following findings from this document refer to this issue: • Cropland dominates the watershed (2006 Land Cover suggests 58%) **(Section Ei)** • Over 1,100 ha of land are within 50 m of a water course, and were annual cropland in 2006 and of high or severe risk of water erosion **(Section Fiv)** • Producers have made significant advances in land management in recent years to address soil erosion, with an almost 50% reduction in the amount of conventional tillage practiced since 1991. This trend is more evident in the upper Pembina watershed where producers are cropping significant amounts of Class 4 land. There has also been a steady increase in the amount of perennial cover in the watershed (e.g. improved pasture and alfalfa) since 1986 **(Section Eii)**	**Water Erosion Mitigation** - Promote and provide technical support for BMPs in prioritized water erosion risk areas (e.g. riparian buffer design and establishment assistance programs)	Areas in the watershed that are: • At high or severe risk of water erosion, in close proximity to waterways and in annual crop production	▪ Proportion of the watershed that is in high or severe risk of water erosion, in annual cropland, and within 50 m of a water course ▪ Proportion of target areas, fitting the above criteria, where certain BMPs are implemented (e.g. cover crops, buffer strips, etc.)
Surface Water Quantity - Drainage and Flooding	**Annual cropping on imperfectly drained soils-** soils and land cover data suggest there are some areas of the watershed that are prone to flooding or possibly increased amount of individual drainage. The following findings from this document refer to this issue: • Average size of these farms, in terms of area per farm, has increased steadily from about 250 ha to about 410 ha, an increase of about 60% **(Section Ei)** • Wetlands occupy significant portions of the watershed (about 4%) and are significantly more common in the westernmost subwatersheds (Pelican and Badger) **(Section Ei)** • About 15,000 ha of land in the watershed that was classified as trees, grassland/pasture or wetland in 1994 was changed to annual cropland in 2006 **(Section Fii)** • Approximately 15% of all annual cropland in Pembina watershed is located on imperfectly drained soils. Potential of increased flooding and drainage with improvements made to imperfect drainage areas are in the headwater wetland areas**(Section Fiv)** • In the upper Pembina watershed where producers are cropping significant amounts of Class 4 land. There has also been a steady increase in the amount of perennial cover in the watershed (e.g. improved pasture and alfalfa) since 1986 **(Section Eii)** • There has been 43 BMPs that have been adopted in the Pembina River Watershed to mitigate soil erosion/flooding. Approximately 54% (23) of those BMPs subscribed are with the Upper Pembina watershed.	Examine the needs for a similar study for **surface water management assessment** as completed with the Turtle Mountain Conservation District (TMCD) for the entire watershed, Examine other **Land Management Opportunities** that provide value to landowner and still maintains the environmental buffer services for wetland or riparian areas) Support the potential development of a **Wetland Restoration Program for the western portion of the watershed** Coordinate BMP initiatives to alleviate regional flooding issues	Areas in the watershed that are: • In the Upper Pembina watershed (Pelican, Badger) • Imperfectly drained soils and annual cropland • Headwater, wetland areas, • Wetland or on class 3 or higher land	Proportion of the watershed that: • Is annual cropland on imperfectly drained soils • Is wetland, tree, grassland/pasture and forage land cover classes • Has BMPs implemented related to flood control and wetland restoration
Soil Degradation	Data from the analysis suggests that there are significant areas of the watershed with high risk of erosion but there are indications of proper mitigation occurring. • Eastern portion of the watershed have reported growing more pulse crops and more areas seeded by conventional tillage **(Section Ei)**. • Cropland dominates the watershed (2006 Land Cover suggests 58%) Approximately 9% (26,586 ha.) of 2006 landcover classified as annual cropland is located on Class 4 and lower **(Section Ei)**. • Analysis shows a decreasing trend since 1994 and 2001 data (including what has been classed In correlation with the decrease in annual cropland, there is a reciprocal increase in forages and grassland from 1994 to 2000. This can be attributed, in part, to the Permanent Cover Program (PCP) introduced in the early 1990s to encourage the conversion of marginal lands from annual cropping production to perennial cover **(Section Eii)**. • Based on 2005 land cover approximately 5% of the annual cropland is located on soils with a high to severe risk for wind erosion **(Section Fii).** • Over 87,000 hectares identified as associated cropland fields next to areas within 50 m of a water course, and of high or severe risk of water erosion **(Section Fiv)**. • Almost 50% reduction in the amount of conventional tillage practiced since 1991 noted in watershed. This trend is more evident in the upper Pembina watershed where producers are cropping significant amounts of Class 4 land. There has also been a steady increase in the amount of perennial cover in the watershed (e.g. improved pasture and alfalfa) since 1986 **(Section Eii).** • The amount of land in fall seeded cereals (winter wheat and fall rye) has shown significant increases since 1986 from about 1,100 ha to a peak of about about 9,800 ha in 2006 **(Section Eii)**. Due to data limitations, further attention to these areas such as site assessments would be required to determine if action (BMP implementation) is indeed warranted	Water **Erosion Mitigation** - Promote BMPs in prioritized water erosion risk areas (e.g. riparian buffer design, Zero Tillage, and establishment assistance programs) for the lower class of lands in severe or highly erosive areas. **Wind Erosion Mitigation** -. Promote BMPs, such as the use of cover crops and residue management techniques, as well as shelterbelt establishment where wind erosion is an issue	Areas in the watershed that are: • In the Eastern Portion of the Pembina watershed • Annual cropped lands of class 4 and lower • At high or severe risk of water erosion and in annual crop production	Areas in the watershed that are: • In high or severe risk of water erosion, in annual cropland, within 50 m of a water course • Contain water erosion mitigation BMPs (e.g. cover crops, buffer strips, etc.) • BMP adoption of BMPS within those critical areas or targeted areas; water quality results or report card larger waterways, • Land Cover Analysis of Forage and
Land Use Planning	Specific recommendations from the IWMP process must be forwarded to local councils for consideration within the Development Plan. These recommendations should take agricultural land management into consideration for preservation of existing farm land and operations.			

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J. Appendices

Appendix A: Mandates of Federal and Provincial Agriculture Departments

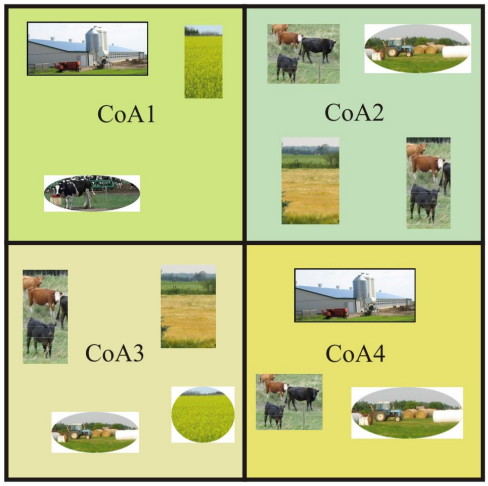
i) **Agriculture and Agri-Food Canada – Agri-Environment Services Branch (AESB)** mission is to provide integrated expertise and innovative environmental solutions to the agriculture and agri-food sector. AESB's focus is on providing knowledge and information; leading adaptation and practice change; and developing and coordinating policy and programs.

ii) **Manitoba Agriculture, Food and Rural Initiatives (MAFRI)**
MAFRI's mission is to assist with the compilation of a technical resource package and deliver expertise with the technical information to aid in issue identification, and to assist the proponent in completing the final Integrated Watershed Management Plan.

Appendix B: Diagram for Interpolating Census of Agriculture Data (Area Weighting Method)

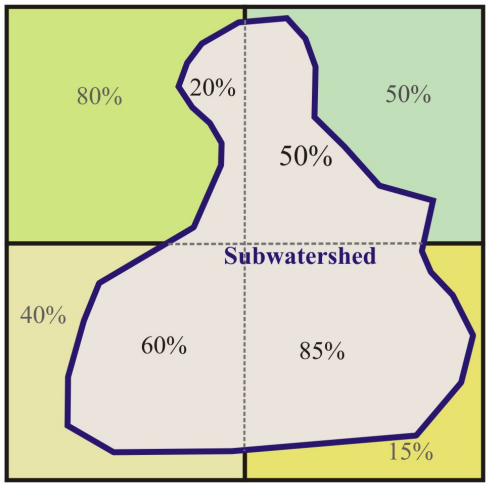
Basic concept of interpolating Census of Agriculture (CoA) using the area weighting method*

Census of Agriculture (CoA) from Statistics Canada's geographic boundaries



CoA from Statistics Canada's geographic boundary

CoA interpolated to subwatershed boundary



CoA is the sum of all survey forms of farms with farm headquarters located in the specific boundary

For Example - Total cattle and calves

CoA1 = 540 total cattle
CoA2 = 300 total cattle
CoA3 = 125 total cattle
CoA4 = 1200 total cattle

Interpolated CoA for Subwatershed =
(CoA1: 540 cattle x 20%) +
(CoA2: 300 cattle x 50%) +
(CoA3: 125 cattle x 60%) +
(CoA4: 1200 cattle x 85%) = 1353.6 total cattle and calves**

** due to the methodology of interpolating data, final census numbers are estimates.

*This is a simplified explanation of the methodology used to interpolated Census of Agricultural data from Statistic Canada's geographic boundaries into other specified boundaries such as watersheds. There are other factors not explained here that are taken into account during the process.

Appendix C: Animal Unit Calculations

Summary of Animal Unit coefficients used in Manitoba as compared to those used for calculations in this report[1]. Assumptions are given in the following Table:

Livestock	Animal Units produced by one animal (MAFRI)	Animal Unit coefficient used in report
Dairy		
Milking Cows (including associated livestock)	2.000	2.000
Beef		
Beef Cows, incl. associated livestock	1.250	1.250
Backgrounder	0.500	\
Summer pasture	0.625	} 0.631
Feedlot	0.769	/
Hogs		
Sows, farrow-to-finish	1.250	--
Sows, farrow-to-weanling	0.313	0.313
Sows, farrow-to-nursery	0.250	--
Weanlings	0.033	--
Grower/finishers	0.143	0.143
Boars (artificial insemination operations)	0.200	0.200
Chickens		
Broilers	0.0050	0.0050
Roasters	0.0100	--
Layers	0.0083	0.0083
Pullets	0.0033	0.0033
Turkeys		
Broilers	0.010	\
Heavy Toms	0.020	} 0.014
Heavy Hens	0.010	/
Horses (PMU)		
Mares, including associated livestock	1.333	1.00
Sheep		
Ewes, including associated livestock	0.200	0.200
Feeder Lambs	0.063	--
Goats	0.143	0.143
Bison		
Cow	1.00	\
Bull	1.00	} 0.8875
Calf	0.25	/
Elk		
Cow	0.53	\
Bull	0.77	} 0.520
Calf	0.05	/

1. An Animal Unit is defined as the number of livestock required to excrete 73 kg (160 lbs) of nitrogen in a 12-month period (as defined in the Farm Practices Guidelines for Poultry Producers in Manitoba)

Summary of assumptions made in calculating Animal Units[1] from 2006 Agricultural Census Data

Livestock	Manitoba Animal Unit Category	Census Category	Assumptions Used for Animal Unit Calculations with census data
Dairy	Milking cows (including associated livestock)	Dairy cows	Assumed categories are equal.
Beef	Beef cows	Beef cows	Assumed number of beef cows reported in 2006 Census equal cow/calf pairs
	Backgrounder Summer pasture Feedlot cattle	Heifers and steers for slaughter or feeding 1 yr and older (combined categories)	Assumed steers and heifers reported in these census categories are split into the three categories (communication with MAFRI). Animal unit coefficient determined using this ratio.
Pigs	Sows, farrow–to-weanling	Sows	Assumed there are no farrow-to-finish operations and no weanling operations in Manitoba – only farrow-to-weanling and grower/finisher operations.
	Grower/finishers	Grower and finisher pigs	
	Boars (artificial insemination operations)	Boars	Assumed all boars reported in the 2006Census are from artificial inseminations.
Chickens	Broilers	Broilers and roasters	Assumed all birds reported in the census category are broilers (communication with MAFRI).
	Layers	Laying hens (19 weeks and older)	Assumed categories are equal.
	Pullets	Pullets (under 19 weeks)	Assumed categories are equal.
	Broiler breeding hens	Laying hens in hatcheries	Assumed all laying hens in hatchery supply flocks reported in Manitoba are broiler breeder hens.
Turkeys	Broiler, Heavy Toms, Heavy Hens	Turkeys	Assumed "turkeys" represents 20% boilers, 40% heavy toms, 40% heavy hens (communication with MAFRI). Animal unit coefficient is determined using this ratio.
Sheep	Ewes, including associated livestock	Ewes	Assumed ewe/lamb pairs (communication with MAFRI).
	Feeder lambs	Lambs	Assumed no feeder lambs in province since numbers are very small and cannot be determined from census data (communication with MAFRI).
Horses	Horses	Total horses and ponies	Assumed each animal produces 1 Animal Unit – PMU farms not identified in Census (communication with MAFRI).
Bison	Bison	Bison	Assumed adults represent 85% and calves represent 15% of bison population in Manitoba (communication with MAFRI). Animal unit coefficient is determined using this ratio.
Elk	Elk	Elk	Number of calves and sex of animals not identified in Census – assumed 45% cows, 35% bulls and 20% calves (communication with MAFRI). Animal unit coefficient is determined using this ratio.
Goats	Goats	Goats	Number of kids and sex of animals not identified in Census – assumed 7 goats make up one Animal Unit, irregardless of age and sex.

1. One Animal Unit is defined as the number of livestock required to excrete 73 kg (160 lbs) of nitrogen in a 12-month period (as defined in the Farm Practices Guidelines for Poultry Producers in Manitoba)

Appendix D: Land Cover Time Frame, Classifications, and Constraints

For the IWMP study area, imagery was available for the years of 1994, 2001-02, and most recently, 2006. Imagery was classified by the Manitoba Conservation - Manitoba Remote Sensing Centre into 16 unique land cover classes. To simplify the analysis, the 16 classes were aggregated into 7 basic land cover classes: annual cropland, forages, grasslands/pasture, trees, wetlands, water, and urban/transportation.

The 1994 land cover used satellite imagery that was captured on May 14th, 1993 for the western edge or the IWMP study area, and imagery from May 26th and October 26th for west central and eastern areas respectively. For the 2001-02 land cover data, the extreme western edge and was analyzed using imagery taken September 14th 2000, the west central area with imagery taken May 18th, 2000, and the eastern portion with imagery from September 3rd, 2001. The 2006 land cover data utilized satellite imagery that was captured on July 14th, 2006 for the majority of the watershed, with a sliver of the watershed that used imagery from June 16, 2005.

Data Constraints

It should be noted that the use of land cover data has limitations from a couple of perspectives. Weather patterns in years leading up to the imagery will impact the cover analysis and may be short term as opposed to a long term trend. Further, past image classifications were undertaken for specific purposes with standardization occurring between 2000-2001 and 2005-2006 as detailed below:

- Classification effort - the 1993 image classification concentrated specifically on annual cropland to aid in delivery of the Western Grains Transportation Payment Program. Greater attention was paid to all classification categories on the 1999-2000 image classification.
- The classification of forages and forages/grasslands - As the land cover classifications could be difficult to interpret given the age of the forage stand and the reflectance of the satellite imagery for classification.
- With respect to the increased level of forages, some of the forage conversion trends may be explained through the adoption of Permanent Cover Program offered by Agriculture Canada in the early 1990s. A program summary for the Pembina River Watershed study area could provide more insight toward understanding the forage trends and if they were indeed related to the Permanent Cover Program, however, the data could not be made available in time for this report. There is some indication from local contacts that the program uptake by producers was low for this watershed, however, without an actual program summary, it cannot be quantified. This information will be available for future reports or for this watershed at a later date.

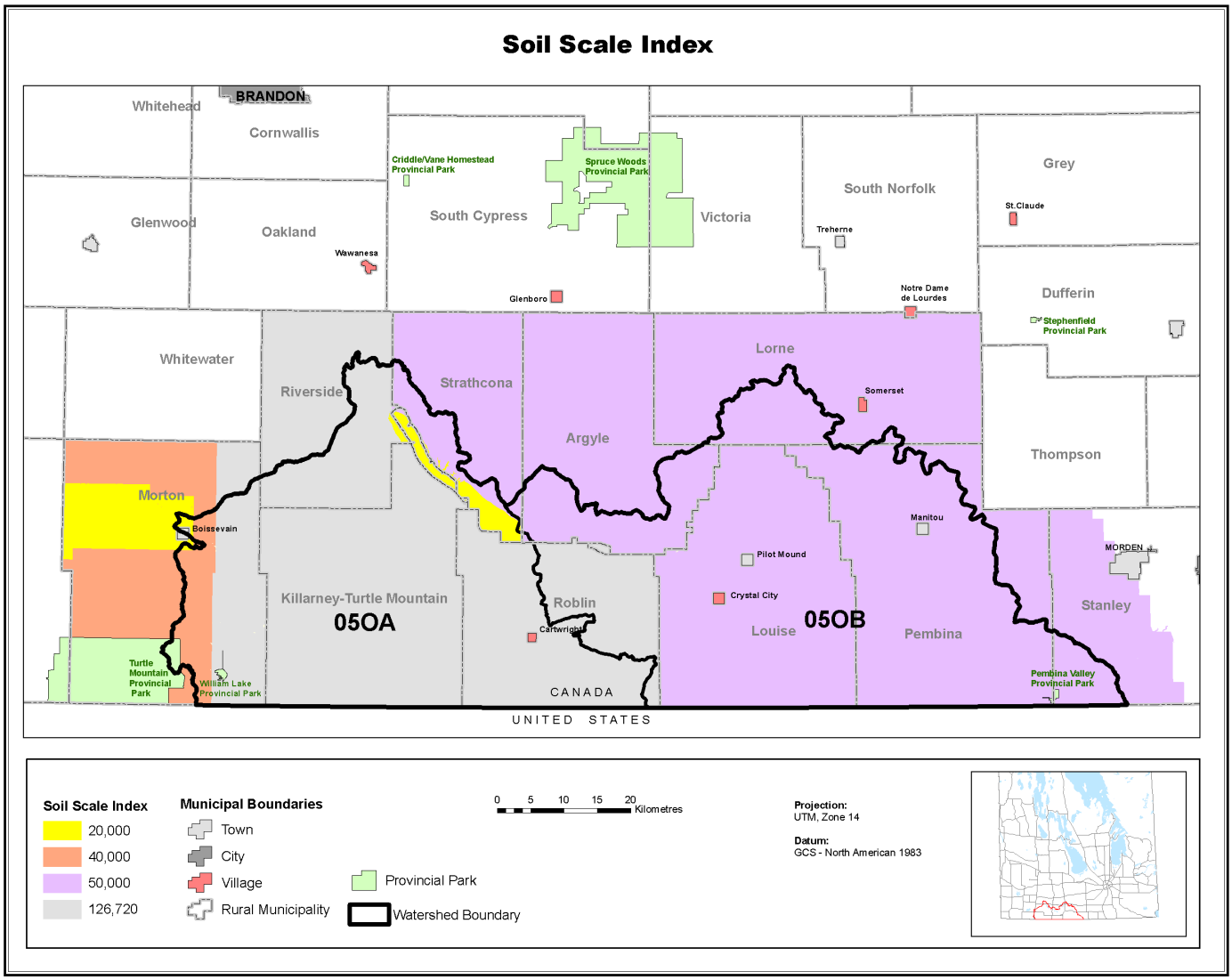
Classification Scheme: Land Cover Mapping of Manitoba	
1. Annual crop land:	Land that is normally cultivated on an annual basis.
2. Forage:	Perennial forages, generally alfalfa or clover with blends of tame grasses.
3. Grassland:	Areas of native or tame grasses, may contain scattered stands of trees
4. Trees:	Lands that are primarily in tree cover
5. Wetlands:	Areas that are wet, often with sedges, cattails, and rushes
6. Water	Open water – lakes, rivers, streams, ponds, and lagoons
7. Urban and Transportation:	Towns, roads, railways, quarries

Appendix E: Soil Information and Background

Soils data within the watershed can be used to provide information on various soil characteristics as well as interpretative ratings such as agriculture capability, water and wind erosion risk. Used in conjunction with the land cover data from 1994-2006, observations about temporal land use trends can be made and used to explain any changes in land management practices.

Soils data within the Pembina River study area has been mapped at different scales of accuracy across the watershed (see figure below). A majority of the eastern side of the watershed has been mapped at 1:50,000, and the western portion being almost completely reconnaissance scale of 1:126,720. There are small pockets on the west side that have more detailed coverage near Boissevain (1:40,000 and 1:20,000) and the Rock and Pelican Lake Area (1:20,000).

A portion of the soil survey information within the Pembina Valley IWMP has been collected at a reconnaissance scale, the data is more suitable for broader landscape based analysis and regional planning purposes. This information is not suitable for site specific planning purposes as more detailed soils information is required for assessments and management considerations at a more detailed scale. Soil information provided in this report is based on the characteristics of the dominant soil series within the various soils polygons.



Appendix F: Canada Land Inventory System Land Classes

Class #	Description
1	Soils in this class have no significant limitations in use for crops.
2	Soils in this class have moderate limitations that restrict the range of crops or require moderate conservation practices.
3	Soils in this class have moderately severe limitations that restrict the range of crops or require special conservation practices.
4	Soils in this class have severe limitations that restrict the range of crops or require special conservation practices or both.
5	Soils in this class have very severe limitations that restrict their capability to produce perennial forage crops, and improvement practices are feasible.
6	Soils in this class are capable only of producing perennial forage crops, and improvement practices are not feasible.
7	Soils in this class have no capability agricultural production.
O	Organic Soils
Source*: Agriculture and Agri-Food Canada*	

Appendix G: Water Erosion Risk

Water erosion information is available as part of the provincial soil survey data that has been compiled from reconnaissance (1:125000 scale) and detailed (1:50000 & 1:20000 scale) soil survey reports. The Universal Soil Loss Equation (USLE) that was developed by Wischmeier and Smith (1965) was used to provide information on water erosion as part of the provincial soils data. The USLE provides a quantitative estimate on the amount of soil that is displaced due to water erosion (either tonne/ha or ton/ac) on an annual basis due to soil, climatic, landscape and management factors that influence the rate of erosion. The USLE can be written as:

A = RKLSCP

Where:

A = Predicted water erosion rate
R = Erosivity of rainfall and snowmelt factor
K = Soil erodibility factor
L = Slope length factor
S = Slope steepness factor
C = Crop cover and management factor (set at 1.0 - assuming bare, unprotected soil)
P = Conservation practice factor (set at 1.0 - assuming no conservation practices)

Due to limitations that are inherent in the model, the lack of the inclusion of conservation management practices and crop cover factors, the numbers that are generated from the USLE should not be used as a value for actual soil loss due to water erosion. However, the USLE is useful in comparing water erosion risk between soils based on their soil/landscape properties and climatic conditions. To accomplish this, the computed USLE values have been compiled into the following 5 group risk classes:

N = Negligible	< 2.7 ton/ac/yr (< 6 tonne/ha)
L = Low	2.7 – 4.9 ton/ac/yr (6 – 11 tonne/ha)
M = Moderate	4.9 – 9.8 ton/ac/yr (11 – 22 tonne/ha)
H = High	9.8 – 14.7 ton/ac/yr (22 – 33 tonne/ha)
S = Severe	> 14.7 ton/ac/yr (> 33 tonne/ha)

By using the risk class groupings, soils can be compared on the basis of their soil physical properties, landscape and climate for resource analysis and targeting of soil conservation programming.

Appendix H: Wind Erosion Risk

Wind erosion information in Manitoba has been developed from the provincial soil survey data and the Soil Landscapes of Canada (SLC Ver 1.0). A geographic information system (GIS) was used to combine both spatial datasets, creating a derived product upon which wind erosion was calculated.

The wind erosion model that is used for the Agriculture Canada Wind Erosion Risk Maps (1989) was applied to the derived dataset. The model was developed from the works of Chepil (1945, 1956) and Chepil and Woodruff (1963) and derives an index value *E* for wind erosion risk (Coote, Eilers & Langman, 1989). The model is stated as:

$$E = kC(V_*^2 - \gamma W^2)^{1.5}$$

Where:

E = maximum instantaneous soil movement by wind (dimensionless)
k = surface roughness and aggregation factor (dimensionless)
C = factor representing soil; resistance to movement by wind (dimensionless)
V_* = drag velocity of wind at soil surface ($cm \cdot s^{-1}$)
γ = soil moisture shear resistance (dimensionless), a value of 5000 was used
W = available moisture of the surface soil ($m^3 water \cdot m^{-3} soil$)

For the analysis, the V_* and *W* values were used from the Soil Landscapes of Canada series. These values are listed for each polygon in the Wind Erosion Risk publication. A listing of *k* and *C* values are also listed in the report and are based on soil surface texture. The values were entered into the database based on soil surface texture types taken from the provincial soil survey data.

Following entering of values for *K*, *C*, *W* and calculating values for V_*, the dimensionless wind erosion index values (*E)* were calculated for each polygon. These values were rated as per the rating system in the Wind Erosion Risk publication.

Class	**E Value**
Negligible	< 100
Low	101 - 250
Moderate	251 - 400
High	401 - 700
Severe	> 700

The ratings are for bare soil and do not consider land use and crop management factors. *E* values were calculated only for those soils within the seamless soil layer that had a mineral soil surface texture rating. Polygons that were rated as being organic soils, bare rock and water in either the seamless soil data or the SLC data did not have *E* values calculated.

For those polygons that have secondary and/or tertiary soils listed within the map unit, a weighted calculation was done based on the percent of occurrence. If organic soils existed in any combination (primary, secondary, tertiary) with mineral soils, weightings were based on mineral soils only.

Appendix I: Soil Drainage Classes

Soil Drainage Class	Description
Very Poor	Water is removed from the soil so slowly that the water table remains at or on the soil surface for the greater part of the time the soil is not frozen. Excess water is present in the soil throughout most of the year
Poor	Water is removed so slowly in relation to supply that the soil remains wet for a large part of the time the soil is not frozen. Excess water is available within the soil for a large part of the time.
Imperfect	Water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season. Excess water moves slowly down the profile if precipitation is the major source
Well	Water is removed from the soil readily but not rapidly. Excess water flows downward readily into underlying materials or laterally as subsurface flow
Rapid	Water is removed from the soil rapidly in relation to supply. Excess water flows downward if underlying material is pervious. Subsurface flow may occur on steep slopes during heavy rainfall.
Source: *System of Soil Classification of Canada – Canada-Manitoba Soil Survey Reports*	

Drainage classification is based on the dominant soil series within each individual soil polygon

Appendix J: 2006 Census of Agriculture Data

Table J1: Agricultural Land Use types reported in the 2006 Census of Agriculture (hectares)

Subwatershed	Total Farmland	Total Cropland**	Summerfallow	Pasture***	Other*
Pelican	95,050	69,210	923	18,762	6,155
Badger	90,868	66,587	817	17,387	6,076
Rock-Swan	120,778	89,381	1,153	21,622	8,621
Snowflake	111,798	84,443	862	19,238	7,254
Pembina	418,494	309,621	3,755	77,010	28,107

*Other category includes all other land uses including farmyard, woodlots, Christmas trees, wetlands, etc.
** Total cropland includes all field crops, vegetables, fruit and nuts and sod
*** Pasture includes tame pasture and natural areas used for pasture.

Table J2: Distribution of crop types as reported in the 2006 Census of Agriculture (hectares)

Subwatershed	Total Cropland*	Cereals	Oilseeds	Pulse	Forage for hay	Forage for seed	Other**
Pelican	69,210	35,344	22,626	1,439	7,863	170	1,768
Badger	66,587	33,556	22,005	585	9,251	275	914
Rock-Swan	89,381	44,328	30,070	789	11,981	353	1,859
Snowflake	84,443	41,275	29,978	1,463	10,373	349	1,005
Pembina	309,621	154,504	104,679	4,276	39,469	1,147	5,546

* Total Cropland includes all field crops, vegetables, fruits and nuts, and sod
** Other category includes other special field crops, fruits and nuts, sod, vegetables, and all suppressed hectares in the listed categories

Table J3: Total area treated with crop inputs for the 2005 cropping year, as reported in the 2006 Census of Agriculture (hectares)

Subwatershed	Use of commercial Fertilizers	Use of Herbicides	Use of Insecticides	Use of Fungicides
Pelican	59,078	57,927	6,120	21,737
Badger	54,876	51,984	5,851	18,695
Rock-Swan	76,754	73,041	9,301	27,261
Snowflake	70,157	66,934	9,953	26,252
Pembina	260,864	249,886	31,224	93,945

Table J4: Total dollars spent on crop inputs for the 2005 cropping year, as reported in the 2006 Census of Agriculture

Subwatershed	Total crop expenses	Total fertilizer and lime	Total herbicides, insecticides & fungicides	Total seed
Pelican	$11,285,381	$5,174,263	$4,048,362	$2,062,757
Badger	$10,843,627	$5,183,711	$3,625,380	$2,034,536
Rock-Swan	$16,080,891	$7,649,524	$5,381,533	$3,049,834
Snowflake	$15,292,879	$7,159,130	$5,031,825	$3,101,925
Pembina	$53,502,779	$25,166,627	$18,087,099	$10,249,052

Table J5: Total number of livestock and poultry on Census Day in 2006, as reported in the 2006 Census of Agriculture

Subwatershed	Total cattle	Beef cows	Dairy cows*	Total Pigs	Sows	Total Poultry
Pelican	18,083	7,284	x	60,162	6,104	5,157
Badger	19,878	8,573	298	67,880	5,243	13,226
Rock-Swan	25,647	11,419	291	41,502	3,190	21,372
Snowflake	21,130	9,277	338	57,730	6,003	108,021
Pembina	84,738	36,554	927	227,275	20,540	147,777

* x - Some suppression of dairy cow numbers occurs in Rock-Swan and Snowflake subwatersheds, and all dairy cow numbers suppressed for Pelican subwatershed

Table J6: Total number farms reporting livestock and poultry on Census Day in 2006, as reported in the 2006 Census of Agriculture

Subwatershed	Total cattle	Beef cows	Dairy cows	Total Pigs	Sows	Total Poultry
Pelican	121	115	4	12	5	13
Badger	128	119	5	16	7	11
Rock-Swan	172	160	8	23	11	9
Snowflake	169	153	8	30	10	16
Pembina	590	547	24	81	33	49

Table J7: Summary of Farm financial characteristics

Subwatershed	Number of Farms	Average farm size (ha)	Average Capital investment ($/farm)	Average livestock-related expenses ($/ha farmland)*	Average crop-related expenses ($/ha farmland)*	Estimated profit ($/farm)*
Pelican	204	466	1,122,637	923	18,762	6,155
Badger	212	428	1,011,855	817	17,387	6,076
Rock-Swan	295	410	1,012,240	1,153	21,622	8,621
Snowflake	323	346	1,054,451	862	19,238	7,254
Pembina	1034	1650	4,201,183	3,755	77,010	28,107

* Calculations are based on the expenses for the 2005 calendar year, as reported in the 2006 Census of Agriculture.

Appendix K: Nutrient Management Regulations

The Nutrient Management Regulation is the first regulation to be passed under *The Water Protection Act*. The purpose is to protect water quality by encouraging nutrient management planning, regulating the application of nitrogen and phosphorus and restricting development within environmentally sensitive areas, especially along natural water systems.

The regulation sets out Nutrient Management Zones based on Canada Land Inventory (CLI) agriculture capability ratings. The various Nutrient Management Zones contain maximum nitrate-nitrogen limits and maximum allowable phosphorus application rates. These can be found on the provincial website at http://www.gov.mb.ca/waterstewardship/wqmz/limitsandthresholds.pdf

Under the regulation, some agricultural operations may be required to file a Nutrient Management Plan (NMP) with Manitoba Water Stewardship.

Effective January 1, 2009, a Nutrient Management Plan must be registered if:

- Nutrients are mechanically applied within Nutrient Management Zone N4 for those agricultural operations in existence prior to November 8, 2006. Nutrient Management Zone N4 consists of CLI class 6 and 7 lands and unimproved organic soils.

Effective January 1, 2011, a Nutrient Management Plan must be registered if:

- Nutrients will be applied to any field that exceeds the residual soil nitrate-nitrogen limits listed in Table 1 for Nutrient Management Zones N1, N2 and N3.
- Nutrients will be applied to any field resulting in soil test phosphorus measuring 60 ppm or more within Nutrient Management Zones N1, N2 and N3 and the phosphorus application rates listed in Table 2 cannot be met.

Table 1. Soil Nitrate-Nitrogen Limits

Nutrient Management Zone	Agriculture Capability Soil Class	Residual Soil Nitrate-Nitrogen Limits within 60 cm (24") of soil
N1	Class 1, 2 and 3 except any 3M subclass	157 kg/ha (140 lb/ac)
N2	Any 3M subclass, class 4 and 5M subclass if it is being irrigated	101 kg/ha (90 lb/ac)
N3	Class 5 except 5M under irrigation	33.6 kg/ha (30 lb/ac)
N4	Class 6, 7 and unimproved organic	No Nitrogen Applications
Nutrient Buffer Zone	Not Applicable	No Nitrogen Applications

Table 2. Soil Test Phosphorus Thresholds and Maximum P Application Rates

Nutrient Management Zone	Soil Test Phosphorus (P) Thresholds within 15 cm (6") of soil (ppm)	Allowable Application Rate of P expressed as P_2O_5 (kg/ha (lb/ac)
N1,N2 and N3	< 60	No restriction
	Between 60 and < 120	Two times crop removal rate
	Between 120 and < 180	One time crop removal rate
	180 or more	No application without approval by the director
N4	No Phosphorus Applications	
Nutrient Buffer Zone	No Phosphorus Applications	

Parcels of land included in a Manure Management Plan registered with Manitoba Conservation do not need to be included in a Nutrient Management Plan submitted to Manitoba Water Stewardship.

Nutrient Buffer Zones apply to all water bodies and groundwater features located across Manitoba. As of January 1, 2009, nutrients containing nitrogen or phosphorus cannot be applied to areas within Nutrient Buffer Zones. The width of the Nutrient Buffer Zone varies depending on the nature of the body of water (Table 3). Certain water bodies have been designated as vulnerable within the Pembina River watershed and have increased setbacks including the Boissevain, Deloraine, Mary-Jane and Goudney reservoirs as well as Killarney Lake.

Table 3: Nutrient Buffer Zones under the Nutrient Management Regulation

Width* of Nutrient Buffer Zones

Water Body	Setback if Nutrient Buffer Zone IS covered with permanent vegetation	Setback if Nutrient Buffer Zone IS NOT covered with permanent vegetation
• a roadside ditch or an Order 1 or 2 drain†	No direct application to ditches and Order 1 and 2 drains	
• a groundwater feature	15 m (49 feet)	20 m (66 feet)
• a wetland, bog, marsh or swamp other than a major wetland, bog, marsh or swamp‡	Distance between the water's edge and the high water mark	
• a lake or reservoir designated as vulnerable**	30 m (98 feet)	35 m (115 feet)
• a lake or reservoir (not including a constructed stormwater retention pond) not designated as vulnerable** • a river, creek or stream designated as vulnerable**	15 m (49 feet)	20 m (66 feet)
• a river, creek or stream not designated as vulnerable** • an Order 3 or higher drain† • a major wetland, bog, marsh or swamp‡ • a constructed stormwater retention pond	3 m (10 feet)	8 m (26 feet)

* ***The Nutrient Buffer Zone is measured out from the water body's high water mark or the top of the outermost bank on that side of the water body, whichever is further from the water.***

† Designated on a Manitoba Water Stewardship plan that shows the designation of drains.

‡ As defined in 1(2) in the Nutrient Management Regulation under the *Water Protection Act.*
"For the purposes of this regulation, a wetland, bog, marsh or swamp is major if
(a) it has an area greater than 2 ha (4.94 acres)
(b) it is connected to one or more downstream water bodies or groundwater features; and
(c) it contains standing water or saturated soils for periods of time sufficient to support the development of hydrophytic vegetation."

** Designated as vulnerable if listed in the Schedule in the Nutrient Management Regulation under the *Water Protection Act.*

Appendix L: Livestock Manure and Mortalities Management Regulation

An Important regulation for agriculture is the Livestock Manure and Mortalities Management Regulation, administered by Manitoba Conservation under the Provincial Environment Act. Details can be found at the provincial government website:

http://www.gov.mb.ca/conservation/envprograms/livestock/index.html

The main points of the legislation are:

- Annual manure management plans are required for operations of 300 animal units or more and cover the storage, handling, disposal and application. These need to be submitted to the department before Feb 10 (for spring application) or July 10 (fall application).
- Manure application is regulated on the basis of residual nitrogen in soil; application rates cannot result in more than 140lbs/acre for Class 1, 2 and 3 (see exception); 90lbs/acre for Class 3M, 3MW and 4; and no more than 30lbs/acre for Class 5 soils
- Annual water analysis required by livestock operations (greater than 300 animal units)
- Winter spreading is prohibited between November 10 and April 10 of following year (with exceptions for operations under 300 Animal Units, pre-1998 operations and applications within defined setback distances)
- Permits are required for the construction of a manure storage facility as well as for a confined livestock facility.

Recent Revisions to LMMR

1. **Phosphorus:** As a result of increasing concerns of rising phosphorus levels in Manitoba, the provincial government has amended the LMMMR regulation. The amendment includes phosphorus as criteria in manure application, as of November 2008.

Some of its key points:

Introduction of soil phosphorus (P) threshold for regulating livestock manure management application:

- If soil test P threshold is 60ppm or less, no restriction on P application (use N-based application)
- If soil P threshold is between 60-119ppm, apply P4 up to 2 times crop removal rate
- If soil P threshold is between 120-179ppm, apply P4 at 1 times crop removal rate
- If soil P threshold is at or above 180ppm, no manure application is allowed without written consent by the Department

2**. Introduction of Special Management Areas (SMA's)** – designating lakes and other watercourses as well as the Red River Valley and other floodplains as areas where special manure management practices are required (no winter application in floodplains; use of buffer strips for water ways).

SMA's require special consideration when implementing management strategies to mitigate the risk of phosphorus loss. They have certain properties of location, soil, climate and landscape (topography) that cause them to be likely sources of phosphorus loss to surface water. The attributes of SMA's provide only limited opportunity for natural attenuation of phosphorus movement before it is transported to surface water. In light of this elevated risk, adoption of beneficial management practices (BMPs) to influence the processes involved in phosphorus transfer to surface water is more critical than in the rest of the landscape. BMPs that inhibit phosphorus mobilization and delivery, in particular, will be important in SMAs.

SMA's in Manitoba have been identified as those areas that are:
• subject to regular inundation, or
• Immediately adjacent to surface water (lakes, rivers, creeks, large unbermed drains, or other watercouses and roadside ditches)

Regularly inundated lands (Red River Valley and Floodplains)
Lands that are subject to regular inundation, whether by overflow from a water body or precipitation and impeded drainage, require special management because of the prolonged contact between water and the soil surface (and particularly exposed manure). Under these conditions, manure could be directly transferred to surface water, especially if the manure has been deposited on frozen ground or on top of the snow. There is also a potential for transfer of
dissolved phosphorus, and to a lesser degree particulate phosphorus, to overlying floodwaters.

Proximity to surface water is not the criterion for designating regularly inundated lands as SMAs – rather, it is the high risk of connectivity between these lands and surface water via surface drainage, whether natural or artificial. Therefore, practices that reduce the exposure of applied manure at the soil surface prior to inundation should reduce the risk of phosphorus transfer to floodwaters and, ultimately, to downstream drains and surface water bodies. One such practice is the elimination of winter applications of manure. Large livestock operations are already prohibited from spreading manure during the winter. Another practice that should reduce the risk of phosphorus transfer to floodwaters is subsurface placement of manure by injection or incorporation following broadcast application. Injection or incorporation of manure is most critical in the fall on regularly inundated lands so that there is minimal or no exposure at the soil surface prior to spring snowmelt. The adoption of this practice is limited by the cropping system (*i.e.,* limited feasibility for perennial forage or reduced-till systems). Special consideration should be given to low or zero disturbance systems that receive manure where full injection or incorporation is not feasible. In these situations, the risk posed by surface application of manure may be partially offset by reduced risk of erosion and runoff, compared to cultivated annual cropland.

Lands immediately adjacent to surface water or watercourses
Lands immediately adjacent to surface water or watercourses are at an elevated risk of contributing phosphorus simply due to their physical proximity. Maintaining narrow strips of perennial vegetation on the edges of tilled fields reduces the direct deposition of manure phosphorus into surface water and watercourses. Direct deposition could also occur via the actual entry of tillage equipment or the movement of soil due to tillage as the equipment passes very near to the waterway. Wider buffer strips along more significant waterbodies help to filter
sediment from runoff before it enters the waterbody.

Harvesting of the perennial vegetation in the buffer strip serves as a means to remove accumulated phosphorus in plant tissue and potentially
provides a source of livestock feed.

No manure phosphorus should be applied to the permanently vegetated buffer strips.

3. POINT SOURCES
Agricultural point sources or "end of pipe" sources include confined livestock areas, manure storage structures or field storage sites, grazing livestock access to watercourses for drinking water, and seasonal feeding areas. The *Livestock Manure and Mortalities Management Regulation* already requires a 100 metre setback from watercourses for any manure storage structures or field storage sites, as well as confined livestock areas. In addition, livestock in confined areas are prohibited from having direct access to surface watercourses.

While direct access to watercourses by grazing livestock is not specifically prohibited by the *Livestock Manure and Mortalities Management Regulation*, direct discharge of manure in surface water is prohibited. The *Protection of Water Sources Regulation* is used to protect surface water sources of community drinking water.

APPLICATION FORMS & REPORTS RELATING TO THE LMMMR

Here are some practical links regarding application forms and other information on manure management (also found on Manitoba Conservation's website):

- Application for Registration of a Manure Storage Facility Without a Permit (française)
- Application for Permit to Construct, Modify or Expand a Manure Storage Facility *(134 Kb pdf file)*
- Construction Requirements for Confined Livestock Areas and Collection Basins
- Application for Permit to Construct, Modify or Expand a Confined Livestock Area
- Obtaining a permit to construct, modify or expand a manure storage facility
- Nutrient Status Report *(18 Kb PDF file)*
- Manure Management Plan Form *(230 Kb DOC file)*
- Manure Management Plan Form *(32 Kb PDF file)*
- MMP Detailed Instructions and Schedules *(104 Kb PDF file)*
- Spreading Confirmation Sheet *(32 Kb PDF file)*
- Manure Management Plan Filer Software

Appendix M: Beneficial Management Practices offered under the Canada Manitoba Farm Stewardship Program 2003-2008

NFSP System Development
BMP Category Code/Practice Code Assignment

NOTE 1: The units of measurement are: distance = kilometers (km), area = acres, volume = cubic meters (m3)

NOTE 2: Funding is expressed as thousands of $ = K (eg. $4K = $4,000)

BMP Category Code	BMP Category Description	BMP Practice Code	BMP Practice Description	BMP Practice Unit Type	Cost Share	Caps
01	Improved Manure Storage and Handling	0101	increased storage to meet winter spreading restrictions (including satellite storage)	volume (m^3)	30%	$30K
		0102	improved features to prevent risks of water contamination (leaks, spills)	N/A		
		0103	slurry storage covers to reduce odours and GHG emissions	N/A		
		0104	containment systems for solid manure (includes covers)	N/A		
		0105	assessment and monitoring of existing manure storage infrastructure	N/A		
		0106	engineering design work (this practice code will stand alone if project does not proceed for economic, technical or environmental reasons (CEAA)	N/A		
02	Manure Treatment	0201	dewatering systems, nutrient recovery systems	N/A	30%	$30K
		0202	composting of manure			
		0203	anaerobic biodigestors			
		0204	engineering design work (this practice code will stand alone if project does not proceed for economic, technical or environmental reasons (CEAA)			
03	Manure Land Application	0301	specialized/modification to equipment for improved manure application	N/A	30%	$10K
04	In Barn Improvements	0401	more efficient livestock watering devices and cleanout systems to reduce water use and decrease manure volumes	N/A	30%	$20K
		0402	engineering design work (this practice code will stand alone if project does not proceed for economic, technical or environmental reasons (CEAA)			
05	Farmyard Runoff Control	0501	upstream diversion around farmyards ;downstream protection (eg. catch basins, retention ponds, constructed wetlands)			

BMP Category Code	BMP Category Description	BMP Practice Code	BMP Practice Description	BMP Practice Unit Type	Cost Share	Caps
05 (cont.)	Farmyard Runoff Control (cont.)	0502	construction of impermeable base and roof for minimizing runoff from livestock pen areas and confinement areas (feed bunks, water infrastructure, walls and electrical costs are not eligible)	N/A	50%	$20K
		0503	engineering design work (this practice code will stand alone if project does not proceed for economic, technical or environmental reasons (CEAA)			
06	Relocation of Livestock Confinement and Horticultural Facilities	0601	relocation of livestock facilities such as corrals, paddocks and wintering sites away from riparian areas	N/A	50%	$30K
		0602	relocation of horticultural facilities such as greenhouses and container nurseries from riparian areas			
		0603	engineering design work (this practice code will stand alone if project does not proceed for economic, technical or environmental reasons (CEAA)			
07	Wintering Site Management	0701	shelterbelt establishment	# kms	50%	$15K
		0702	portable shelters and windbreaks	# kms		
		0703	alternative watering systems (ie: solar, wind or grid power)	N/A		
		0704	field access improvements: alleyway/access lane upgrades	# kms		
		0705	fence modifications	# kms		
08	Product and Waste Management	0801	improved on-farm storage and handling of agricultural products (eg. fertilizer, silage, petroleum products, and pesticides)	N/A	30%	$15K
		0802	improved on-farm storage, handling, and disposal of agricultural waste (eg. livestock mortalities, fruit and vegetable cull piles, wood waste)			
		0803	composting of agricultural waste (eg. Livestock mortalities fruit, vegetable, wood, straw residue)			
		0804	engineering design work (this practice code will stand alone if project does not proceed for economic, technical or environmental reasons (CEAA)			
09	Water Well Management	0901	sealing & capping old water wells	N/A	50%	$6K
		0902	protecting existing water wells from surface contamination			
10	Riparian Area Management (GREENCOVER)	1001	alternative watering systems (ie: solar, wind or grid power)to manage livestock:	N/A		

BMP Category Code	BMP Category Description	BMP Practice Code	BMP Practice Description	BMP Practice Unit Type	Cost Share	Caps
10 (cont.)	Riparian Area Management (GREENCOVER) (cont.)	1002	buffer establishment and planting of forages (planting and establishment costs for trees and shrubs for the year of planting and one year after the planting year, or the termination of the NFSP funding, whichever comes first)	# acres	50%	$20K
		1003	fencing to manage grazing and improve riparian condition/function	# kms		
		1004	native rangeland restoration or establishment: native species of forages, shrubs, and trees	# acres		
		1005	grazing management in surrounding uplands: alternative watering systems (ie: solar, wind or grid power) and cross fencing	# kms offence		
		1006	improved stream crossings	N/A		
11	Erosion Control Structures(Riparian) (GREENCOVER)	1101	constructed works in riparian areas: contour terraces, gully stabilization, bank stabilization, erosion control matting, silt fencing, drop inlet and enhanced infiltration systems, in-channel control, retention ponds and erosion control dams	N/A	50%	$20K
		1102	engineering design work (this practice code will stand alone if project does not proceed for economic, technical or environmental reasons (CEAA)			
12	Erosion Control Structures(Non Riparian)	1201	constructed works in non riparian areas: contour terraces, gully stabilization, bank stabilization, erosion control matting, silt fencing, drop inlet systems and enhanced infiltration systems, in-channel control, retention ponds and erosion control dams, mechanical wind screens	N/A	50%	$20K
		1202	engineering design work (this practice code will stand alone if project does not proceed for economic, technical or environmental reasons (CEAA)			
13	Land Management for Soils at Risk	1301	forage or annual barrier establishment for soils at risk (eg. stripcropping, grassed waterways, perennial forages on severely erodible or saline soils)	# acres	50%	$5K
		1302	straw mulching	# acres		
		1303	grazing management in critical erosion areas not associated with riparian zones: alternative watering systems (ie: solar, wind or grid power), crossfencing	# kms offence		
14	Improved Cropping Systems	1401	equipment modification on pre-seeding implements for restricted zone tillage for row crops, seeding and post seeding implements for low disturbance placement of seed and fertilizer	N/A	30%	$15K
		1402	chaff collectors and chaff spreaders installed on combines			

BMP Category Code	BMP Category Description	BMP Practice Code	BMP Practice Description	BMP Practice Unit Type	Cost Share	Caps
14 (cont.)	Improved Cropping Systems (cont.)	1403	precision farming applications: GPS information collection, GPS guidance (ie: autosteer, lightbars, software) , manual and variable rate controllers for variable fertilizer application			
15	Cover Crops	1501	establishment of non-economic cover crop	# acres	30%	$5K
		1502	equipment modification for inter row seeding of cover crops (eg. relay crops)	N/A		
16	Improved Pest Management	1601	equipment modification for improved application	N/A	30%	$5K
		1602	information collection and monitoring			
		1603	biological control agents			
		1604	cultural control practices			
		1605	mobile water tanks			
17	Nutrient Recovery from Waste Water	1701	recycling of waste water streams from milkhouses, fruit and vegetable washing facilities, and greenhouses in order to recover nutrients	N/A	30%	$20K
		1702	engineering design work (this practice code will stand alone if project does not proceed for economic, technical or environmental reasons (CEAA)			
18	Irrigation Management	1801	irrigation equipment modification/improvement to increase water or nutrient use efficiency	N/A	30%	$10K
		1802	equipment to prevent backflow of altered irrigation water into water sources			
		1803	improved infiltration galleries and irrigation intake systems			
19	Shelterbelt Establishment (GREENCOVER)	1901	establishment of shelterbelts for farmyard, live stock facilities, dugout snowtrap, wildlife habitat enhancement, field (planting and establishment costs for trees and shrubs for the year of planting and one year after the planting year, or the termination of the NFSP funding, whichever comes first)	# kms	50%	$10K
		1902	tree materials required for shelterbelt establishment	N/A		
20	Invasive Alien Plant Species Control	2001	integrated approaches (cultural, mechanical, and biological) for control of invasive plant species (eg. leafy spurge, purple loosestrife, scentless chamomile)	N/A	50%	$5K
21	Enhancing Wildlife Habitat and Biodiversity	2101	buffer strips: native vegetation	# acres		
		2102	alternative watering systems (ie: solar, wind or grid power)	N/A		

BMP Category Code	BMP Category Description	BMP Practice Code	BMP Practice Description	BMP Practice Unit Type	Cost Share	Caps
21 (cont.)	Enhancing Wildlife Habitat and Biodiversity (cont.)				50%	$10K
		2103	improved grazing systems: crossfencing	# kms		
		2104	wildlife shelterbelt establishment	# kms		
		2105	improved stream crossings	N/A		
		2106	hayland management to enhance wildlife survival	N/A		
		2107	wetland restoration	acres		
22	Species at Risk	2201	alternative watering systems (ie: solar, wind or grid power)	N/A	50%	$10K
		2202	improved grazing systems: crossfencing	# kms		
		2203	plant species establishment	# acres		
		2204	infrastructure development and relocation	N/A		
23	Preventing Wildlife Damage	2301	forage buffer strips	# acres	30%	$10K
		2302	fencing or netting to protect stored feed, concentrated livestock, high value crops, drip irrigation systems, and other ag. activities	# km offence		
		2303	scaring and repellant systems and devices	N/A		
24	Nutrient Management Planning	2401	consultative services to develop nutrient management plans, planning and decision support tools	# acres	50%	$4K
25	Integrated Pest Management Planning	2501	consultative services to develop integrated pest management plans, planning and decision support tools	# acres	50%	$2K
26	Grazing Management Planning (GREENCOVER)	2601	consultative services to develop range and grazing management plans, planning and decision support tools	# acres	50%	$2K
27	Soil Erosion and Salinity Control Planning	2701	consultative services to develop soil erosion and salinity control plans, planning and decision support tools	# acres	50%	$2K
28	Biodiversity Enhancement Planning	2801	consultative services to plan habitat enhancement, wetland restoration, stewardship for species at risk and/or wildlife damage prevention within agricultural land base; planning and decision support tools	# acres	50%	$2K

BMP Category Code	BMP Category Description	BMP Practice Code	BMP Practice Description	BMP Practice Unit Type	Cost Share	Caps
29	Irrigation Management Planning	2901	consultative services for planning improved water use efficiency and reduced environmental risk of existing irrigation systems, planning and decision support tools	# acres	50%	$2K
30	Riparian Health Assessment (GREENCOVER)	3001	consultative services for assessing riparian health, planning and decision support tools	# acres	50%	$2K

Appendix N: Environmental Farm Plan Workshops and EFP Statement of Completions in Manitoba