Water Uses

Surface Water Quantity Indicator

The natural flow regime in the majority of Saskatchewan's watersheds has been altered by changes in land use, water withdrawals, and structures such as dams and low-level crossings. To assess the potential impact of flow alteration, this indicator compares the difference between the average natural flow regime to the average actual flow within each watershed.

Indicator	
Surface Water Quantity	**Status:** Research is currently being done in Saskatchewan to assess the in-stream flow needs of a number of waterways. **Trend:** It is difficult to calculate trends as flow is highly variable and this indicator only assesses annual flow.

The issue
Natural fluctuations in water flows are integral for sustaining the biodiversity and the health of connected ecosystems, such as wetlands and riparian areas. Changes in flow regimes affect the aquatic ecology of these ecosystems and may result in alterations in aquatic habitat, aquatic communities, biogeochemical cycles, riparian zones, floodplains and wetlands, altered riparian communities due to changes in flooding patterns, water levels, water temperature, and the stability of river channels (Dynesius and Nillson 1994). According to the World Commission on Dams (2000), flow pattern is the most important factor affecting the structure and integrity of downstream aquatic ecosystems. The Commission found that aquatic communities in rivers with a naturally variable flow are typically distinct from those communities in rivers with a highly regulated flow.

The volume of flow within a watershed is affected by several factors, including:
- precipitation;
- soil infiltration rate;
- ground water discharge;
- evapotranspiration;
- aquatic fragmentation and water regulation;
- water withdrawals; and
- water inputs from anthropogenic sources such as irrigation, wastewater, and stormwater runoff from impervious areas.

Surface Water Quantity Indicator in Saskatchewan

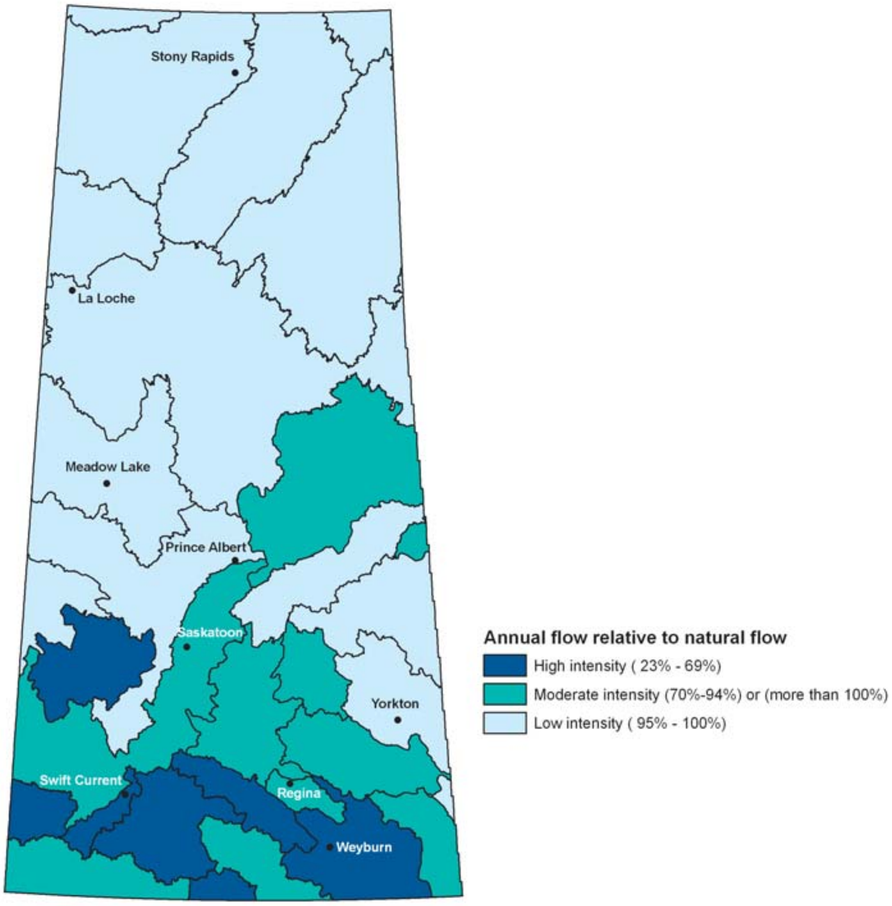

Figure 63. Average annual recorded flow volume as a percentage of natural flow volume.

The average annual recorded flow volume relative to the annual natural flow volume is classified as healthy for 13 watersheds, stressed for nine watersheds, and impacted for seven watersheds. The Lower and Upper Qu'Appelle River Watersheds are classified as stressed, as both watersheds have a higher recorded flow volume than is natural. The additional flow in these two watersheds is the result of the diversion of water from the South Saskatchewan River.

Indicator		
Average Annual Recorded Flow as a Percentage of Natural Flow	=	$\frac{\text{Annual recorded flow volume (dam}^3)^*}{\text{Annual natural flow volume (dam}^3)^{**}}$

*Annual recorded flow volume is the actual median flow volume recorded.
**Annual natural flow volume is the estimated median flow in the absence of any human modification (e.g., dams, reservoirs, irrigation, allocation).

Rating Scheme
The surface water quantity rating scheme is based on the maintenance of ecological health. The three categories for this indictor were derived as a result of expert opinion.

Surface Water Quantity
Low intensity: The average annual recorded flow volume accounts for greater than 94% of the natural flow volume.
Moderate intensity: The average annual recorded flow volume accounts for between 70% and 94% of the natural flow volume.
High intensity: The average annual recorded flow volume accounts for less than 70% of the natural flow volume.

Data Source: The average natural and average recorded flow volumes are based on hydrometric data gathered by Environment Canada, the Saskatchewan Watershed Authority, and the Prairie Provinces Water Board. The average natural and average recorded flow volumes were calculated using flow data from the most recent 30 years, or from all available years. Internal surface water allocations and losses were obtained from the Saskatchewan Watershed Authority's Surface Water Allocation Database.

Data Discussion: It is difficult to calculate trends in the data as flow is highly variable and this indicator only assesses annual flow. It is the hope that this indicator will be improved for the next State of the Watershed Report by looking at changes in recorded seasonal flow compared to seasonal natural flow.

Response to the issue
To address the potential impact of development and climate change on flow, in 2009 the Saskatchewan Watershed Authority initiated the Water Availability Study. One of the components of this study is to model and assess the potential impact current, proposed, and potential developments, combined with climate change, will have on flows in the North and South Saskatchewan Rivers and the Qu'Appelle Diversion.

The Saskatchewan Watershed Authority Act, 2005, administered by the Saskatchewan Watershed Authority, in part accounts for and regulates the alteration of surface water flow. The Act regulates:

- the construction, extension, alteration and operation of any works (e.g. dykes, dams, weirs, floodgates, breakwaters, reservoirs, canals, tunnels, bridges, and culverts) in Saskatchewan; and
- surface water allocation by issuing approvals to construct and operate works and water rights licenses, with the exception of domestic use.

In addition to legislation, monitoring programs have also been established in the province to assess surface water quantity (see the **Water Quantity Monitoring and Management** in Appendix C). Some of the government-initiated monitoring programs include:

- the Water Survey of Canada, an Environment Canada initiative;
- the Prairie Provinces' Water Board; and
- the Saskatchewan Watershed Authority's Provincial Streamflow Forecast.

Surface Water Allocation Indicator

To assess the potential impact of surface water allocation, this indicator determines the percentage of natural flow that is allocated for various human activities.

Indicator	
Surface Water Allocation	**Status:** Surface water allocation is highest in southern Saskatchewan, where the majority of the population is located. **Trend:** It is very difficult to calculate trends as flow is so variable. Surface water allocation has remained relatively constant since this indicator was first reported, in the 2007 *State of the Watershed Report*.

The issue

Surface water allocation is the volume of water licensed for a project that the project is allowed to withdrawal from a surface waterbody. When water is allocated through the licensing process, the purpose for which the water will be used is specified. Based on this information, the main uses of surface water in Saskatchewan include: industrial uses, which accounts for 39% of all provincial allocations; irrigation, which accounts for 37% of all provincial allocations; and municipal use, which accounts for 16% of all allocations. In Saskatchewan, municipal or communal waterworks that use surface water serve approximately 57% of the provincial population, or about 551,850 people (SaskH_2O 2009).

This indicator measures the total volume of surface water allocated to various human activities. The indicator shows to what extent surface water resources are currently allocated, and provides information on the intensity of water allocation at a watershed level.

Surface Water Allocation Indicator in Saskatchewan

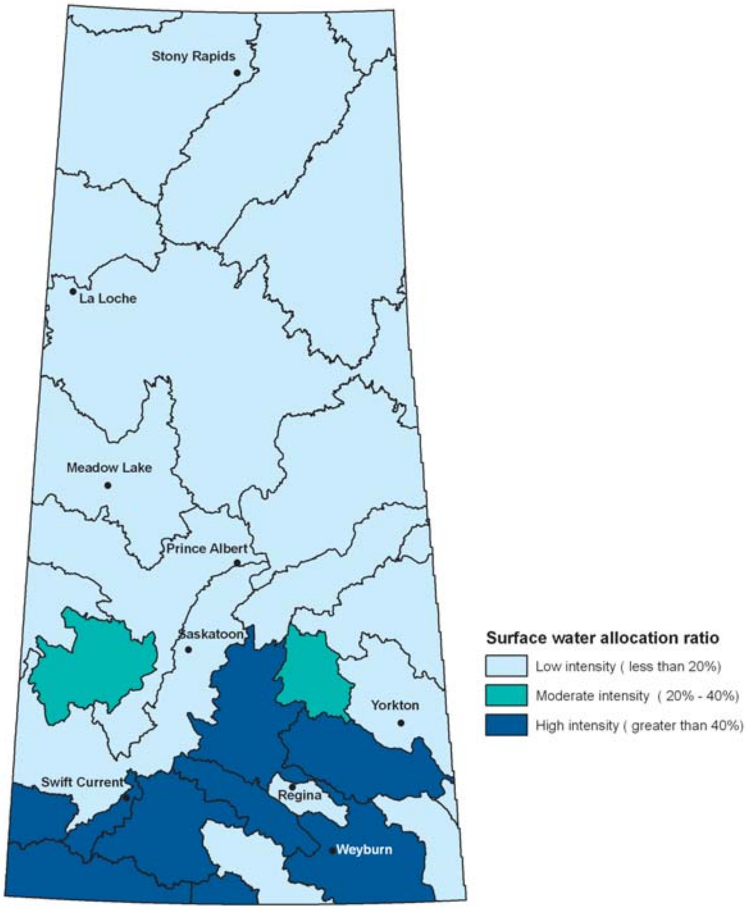

Figure 64. Surface water allocation ratio by watershed.

Twenty of the watersheds in Saskatchewan currently have a surface water allocation ratio of less than 35%. The Upper and Lower Qu'Appelle River, Moose Jaw River, Upper Souris River, Swift Current Creek, Old Wives Lake, Milk River, Poplar River, and Cypress Hills North Slope Watersheds all have surface water allocation ratios greater than 40%, which has the potential for placing high stress on these watersheds. These values do not represent the actual water used or consumed, but rather the amount of water that is allocated for use. The majority of these allocations do not consume the full amount they have been allocated.

Indicator				
Surface Water Allocation Ratio	=	$\dfrac{\text{Annual diversion (dam}^3\text{)}^{*}}{\text{Annual natural flow volume (dam}^3\text{)}^{**}}$	x	100

*Annual diversion is the licensed amount of allocation added to the loss, where the loss represents volume lost due to evaporation and ground water recharge on an annual basis.
**Annual natural flow volume is the estimated median flow in the absence of any human modification (e.g., dams, reservoirs, irrigation, allocation).

Rating Scheme
The surface water allocation rating scheme takes into consideration the Prairie Provinces Water Board's 1969 Master Agreement on Apportionment. Under this agreement, if a watershed is part of an international or inter-provincial basin, the Province of Saskatchewan must provide 50% of the estimated median annual flow to the receiving jurisdiction.

Surface Water Allocation
Low intensity: Surface water allocation and losses are less than 20% of the natural flow.
Moderate intensity: Surface water allocation and losses are between 20% and 40% of the natural flow.
High intensity: Surface water allocation and losses are greater than 40% of the natural flow.

Methods: The methods used to calculate this indicator have changed from the 2007 *State of the Watershed Report*. In the 2007 report, the surface water allocation ratio was obtained by dividing the diversion by the supply, where the supply is the estimated median annual recorded flow. In this report, the surface water allocation ratio was obtained by dividing the diversion by the natural flow volume, where the annual natural flow volume is the estimated median flow in the absence of any human modification (e.g., dams, reservoirs, irrigation, allocation). Because the calculations have changed from the 2007 report, the Surface Water Allocation indicator in the 2007 report is not comparable to this indicator.

Data Source: Allocation and loses were obtained from the Saskatchewan Watershed Authority's Surface Water Allocation Database, March 2006. The average natural recorded flow volumes are based on hydrometric data gathered by Environment Canada, the Saskatchewan Watershed Authority, and the Prairie Provinces Water Board. The average natural recorded flow volumes were calculated using flow data from most recent 30 years, or from all available years.

Data Discussion: Available data do not allow calculation of water use. Instead, what is proposed is to determine the ratio of allocation to supply. Allocation and use are not synonymous: allocation refers to the volume of water that a project is allowed to withdraw; use refers to the volume that is actually withdrawn. Actual water use may be less than that allocated.

Response to the issue
Surface water allocation in Saskatchewan is regulated by the Saskatchewan Watershed Authority, through *The Saskatchewan Watershed Authority Act, 2005*. The Act mandates that the Authority: manage and protect Saskatchewan's source water, watersheds and related lands; promote water conservation; regulate water development and water use; and promote research and conservation programs related to the aforementioned activities.

The Saskatchewan Watershed Authority recognizes the importance of flows for the ecological (physical, chemical and biological) health of streamcourses. Currently, dams are informally and proactively operated to maintain minimum flows for some targeted aspects of ecological health. In addition to maintaining minimum flows, the variability and timing of flows can also be ecologically important. The Authority is currently researching methods of determining and achieving sustainable flows that can best meet watershed health objectives, while maintaining domestic, municipal, industrial, and irrigation water needs.

Ground Water Use Indicator

This indicator measures both the density of ground water wells and the allocation of ground water by watershed in Saskatchewan.

Density of Ground Water Wells	**Status:** As of May 2009, there were 120,464 ground water wells that had been entered into the Saskatchewan Watershed Authority's Water Well Driller's Records Database. **Trend:** The density of ground water wells is increasing in Saskatchewan.
Allocation of Ground Water	**Status:** The majority of ground water in Saskatchewan is allocated for industrial (52%) and municipal (45%) purposes. This does not include ground water diversions of less the 5,000 cubic metres per year for domestic purposes, which do not require an allocation from the Saskatchewan Watershed Authority. The method used to calculate the Ground Water Use indicator has been revised from the one used to calculate the Ground Water Allocation indicator in the 2007 *State of the Watershed Report* (see the **Methods** section on page 11 for details). **Trend:** The allocation of ground water remained constant between the 2007 *State of the Watershed Report* and this report.

The issue
Ground water represents a reliable water source for many individuals, municipalities and industries. This is particularly important in Saskatchewan because, unlike surface waters, it is not as readily influenced by short-term fluctuations in climate variability. As an integral component of the hydrologic cycle, the status of ground water is an important component in defining the health of watersheds and the long-term economic potential in many regions of the province. One means of assessing the status of ground water resources is to evaluate human use in order to determine the potential impact on the supply and health of ground water (Rutherford 2004).

The density of ground water wells is used in this report as an indicator of the potential impact humans are having on ground water quality. If they are not properly built or maintained, ground water wells can act as conduits for contaminants to reach aquifers. The greater the density of wells in a watershed, the greater the potential for ground water contamination.

Estimating the impact of humans on ground water quantity is challenging. Through an assessment of ground water yield, a comparison can be made between the annual allocation rates and the amount of ground water available for use. However, because of the intensive data collection and analysis required, there are few aquifer systems in Saskatchewan where there are reasonable estimates of the well yield. In fact, the only two areas where there are reasonable estimates of well yield are in the Regina and Yorkton areas. Due to the limited availability of detailed studies on ground water yield, the potential stress from human activities on ground water quantity is assessed using annual allocation rates as a proxy measurement.

Ground Water Use Indicator in Saskatchewan

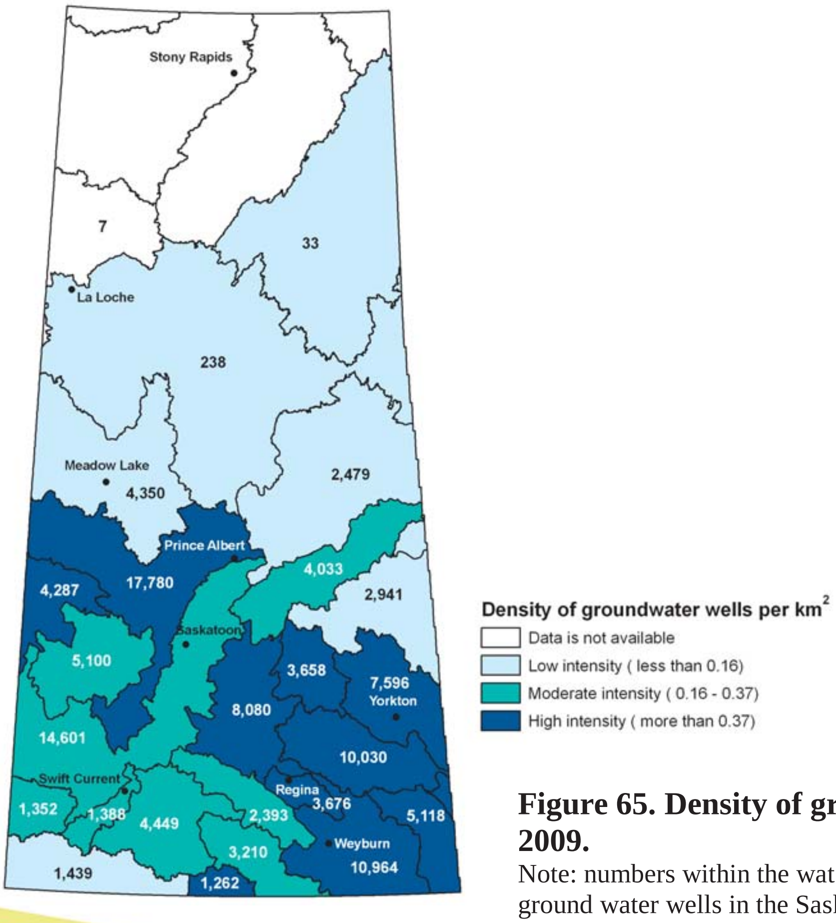

Figure 65. Density of ground water wells by watershed: 2009.

Note: numbers within the watershed boundaries represent the number of ground water wells in the Saskatchewan Watershed Authority's Water Well Driller's Records Database.

Among the 24 watersheds for which data are available, the density of ground water wells is classified as low intensity for six watersheds, moderate intensity for eight watersheds, and high intensity for 10 watersheds.

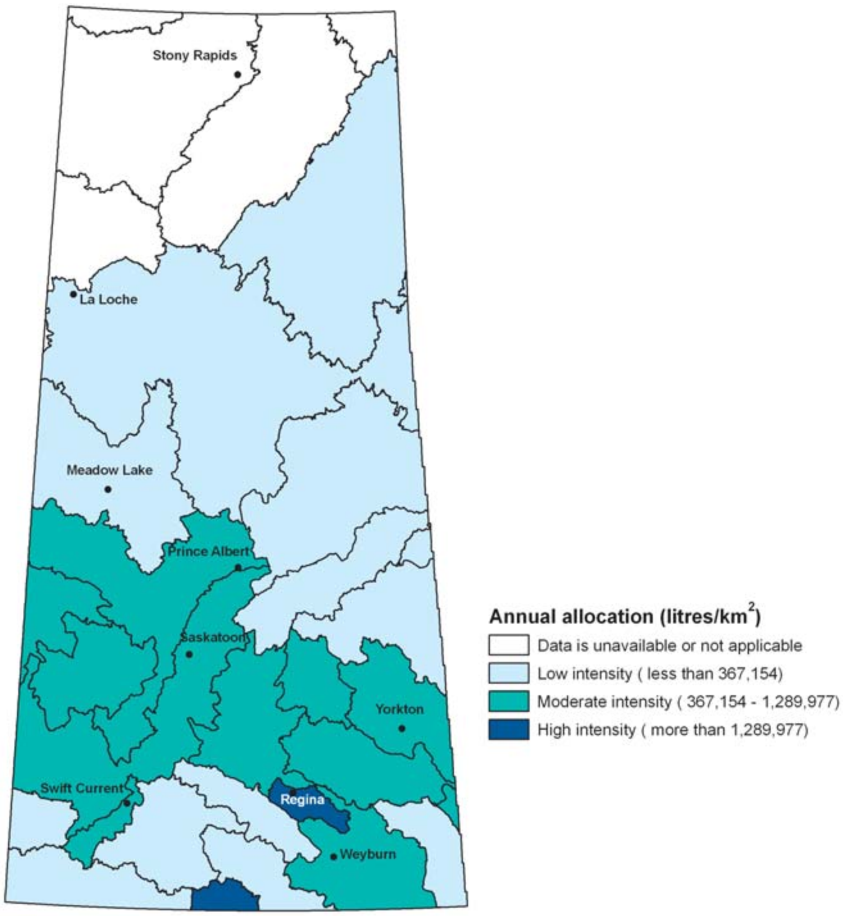

Figure 66. Ground water allocation per square kilometre, by watershed: 2009.

In 2009, ground water allocation per square kilometre was low in 12 watersheds, moderate in ten watersheds, and greatest for the Wascana Creek and Poplar River Watersheds. Of the total amount of ground water allocated in Saskatchewan, 52% was allocated for industrial use, followed by municipal use (44%), irrigation (2%), other use (2%), and domestic use and multi-purpose use (less than 1%).

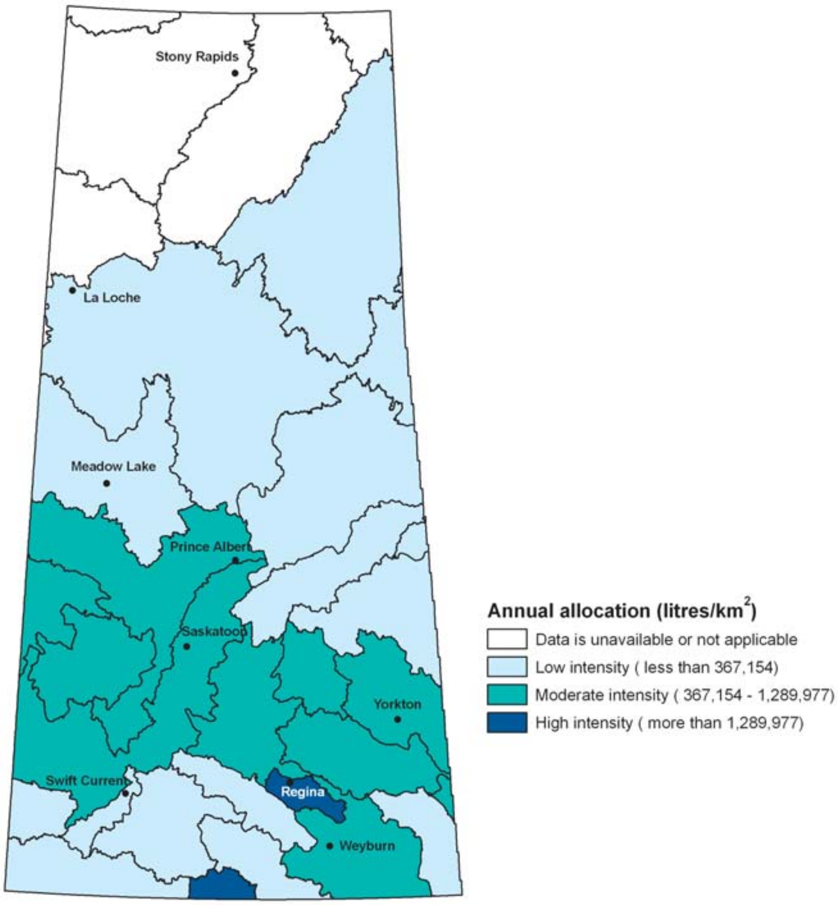

Figure 67. Ground water allocation per square kilometre, by watershed: 2007.

In 2007, ground water allocation per square kilometre was low in 13 watersheds, moderate in nine watershed, and greatest in the Wascana Creek and Poplar River Watersheds. Between 2007 and 2009, the Swift Current Creek Watershed was the only watershed that moved between rating classes. It moved from low intensity to moderate intensity for ground water allocation.

Indicator		
Density of Ground Water Wells	=	$\frac{\text{Number of ground water wells}}{\text{Watershed area (km}^2\text{)}}$
Ground Water Allocation	=	$\frac{\text{Annual approved ground water allocation for projects (litres/yr)}}{\text{Watershed area (km}^2\text{)}}$

Rating Scheme
Insufficient data from appropriate scientific studies existed to rate this indicator, so the Jenks' optimization method was used to identify the natural breaks in the data.

Ground Water Well Density
Low intensity: Less than 0.16 wells per square kilometre.
Moderate intensity: Between 0.16 and 0.37 wells per square kilometre.
High intensity: More than 0.37 wells per square kilometre.

Ground Water Allocation
Low intensity: Less than 367,154 litres per square kilometre.
Moderate intensity: Between 367,154 and 1,289,977 litres per square kilometre.
High intensity: More than 1,289,977 litres per square kilometre.

Methods: The method used to calculate the Ground Water Use Indicator in the 2007 State of the Watershed Report has been revised from the one used to calculate the Ground Water Allocation Indicator. The 2007 *State of the Watershed Report* reported on the annual approved ground water allocation within a watershed, while this report takes this a step further by detailing the annual approved ground water allocation divided by the area of the watershed.

Data Source: The number of ground water wells was obtained from the Saskatchewan Watershed Authority's Water Well Driller's Records Database, 2009. Ground water allocation data were obtained from the Saskatchewan Watershed Authority's Licensed Ground Water Database, April 2009.

Data Quality/Caveats: The basin and sub-basin fields in the Licensed Ground Water Database are based on drainage boundaries, not geologic formation boundaries. A comparison of the watershed and drainage basin map boundaries needs to be conducted to determine the allocation information for a watershed. Annual ground water allocation is the amount of ground water allowable for extraction; it is not the actual amount the project uses. Actual annual extraction information is not typically reported, and therefore it is not included in the Licensed Ground Water Database. Ground water allocations from domestic wells within the home quarter are not included in Figures 66 and 67. Domestic wells are not pursuant to *The Saskatchewan Watershed Authority Act, 2005* and do not require approval for the ground water works unless the water is used away from the home quarter.

Response to the issue
The primary response to ensure sustainable ground water allocation in Saskatchewan is through ground water licensing.

Ground water allocation is regulated by the Saskatchewan Watershed Authority through *The Saskatchewan Watershed Authority Act, 2005* and *The Ground Water Regulations*.

The Saskatchewan Watershed Authority Act, 2005 mandates that the Authority: manage and protect Saskatchewan's source water, watersheds and related lands; promote water conservation; regulate water development and water use; and promote research and conservation programs related to the aforementioned activities.

The Ground Water Regulations controls the exploration and use of ground water through the establishment of a permit system. The regulations set out requirements that the owner and driller must comply with, including registering machinery, submitting drilling records, well disinfection and construction methods, test hole abandonment procedures, and licensing and use of ground water.

Under the Act, all ground water use except for domestic purposes requires an approval. The Saskatchewan Watershed Authority's regulatory approval process for development of a ground water source project requires that the proponent obtain:

1) a Ground Water Investigation Permit; and
2) an Approval to Construct and Operate Works and Water Rights Licence to Use Ground Water.

Not all of the water wells accounted for in Figure 65 are active wells; some are abandoned or decommissioned wells. Decommissioning abandoned wells is one way of reducing both the density of wells in a watershed and also the threat of ground water contamination from abandoned wells. There are many ways to decommission a well, as procedures vary depending on well construction, hydrogeology and geology of the site. General guidelines for well decommissioning procedures can be found in the document entitled *A Landowner's Guide to Water Well Management* (Mance 2007) and also in a short six-minute abandoned water well decommissioning video entitled "*Abandoned Water Well Decommissioning: Protecting Our Precious Resources*" (Saskatchewan Watershed Authority and Agriculture and Agri-Food Canada 2008). This video can be found on-line at: http://www.swa.ca/WaterManagement/Groundwater.asp?type=WellDecommissioning.

In addition to water well decommissioning, *A Landowner's Guide to Water Well Management* (Mance 2007) provides landowners with a list of preventative measures that they can follow to help reduce the risk of contaminating their well and associated aquifers. Some of these measures include ensuring:

- wells are constructed properly;
- inactive wells are properly decommissioned;
- onsite sewage systems are properly constructed;
- fuel is stored in properly installed, approved tanks that resist corrosion and that fuel storage tank dispensers meet legislated requirements;
- fuel tanks are regularly monitored for leaks;
- pesticides and fertilizers are handled carefully, and mixed and stored away from a well site;
- regularly testing soil and manure to reduce the risk of leaching of nutrients from excess application of fertilizer and manure;
- silage is stored at an appropriate moisture level to minimize seepage and that the silage storage site is in good condition;
- livestock yards are located away from nearby wells, and manure and runoff is collected and stored; and
- farm wastes are properly disposed of (Mance 2007).

Human Influences

Human Population Indicator

This indicator was designed to identity the impacts of human population at the watershed level. Three rating schemes are employed: one to rate the relative population between watersheds, one to assess the relative change in population size over time, and one to assess the relative population density between watersheds.

Indicator	
Population Size	**Status:** The population of Saskatchewan in 2006 was 968,157. **Trend:** The population of Saskatchewan in 2006 declined by 10,776 people (1.1%) since 2001 (Statistics Canada 2007).
Population Change	**Status:** Population continues to decline in Saskatchewan. **Trend:** The South Saskatchewan River and Churchill River Watersheds continue to increase in population. The two cities in Saskatchewan with the greatest growth rate are Saskatoon and Lloydminster.
Population Density	**Status:** Population density has remained the same in all watersheds in both the 2001 and 2006 Census years. **Trend:** Population density in Saskatchewan has remained stable.

The issue
Changes in the number of people living in Saskatchewan, and within each watershed, can place pressures on the supporting environment through the accompanying land use changes required to accommodate these people. Land use changes can include converting agricultural or wildlife habitat land to urban use, releasing wastewater into surface waterbodies, and increased water allocations.

The population of Saskatchewan declined 1.1% between 2001 and 2006. The majority (52%) of Saskatchewan's population lives within the province's four largest cities: Saskatoon, Regina, Prince Albert, and Moose Jaw. The two cities in Saskatchewan with the greatest growth rate since 2001 were Saskatoon (3.5%) and Lloydminster (2.7% in the portion within Saskatchewan). There was a decline in Saskatchewan's rural population between 2001 and 2006 of 3%.

Human Population Indicator in Saskatchewan

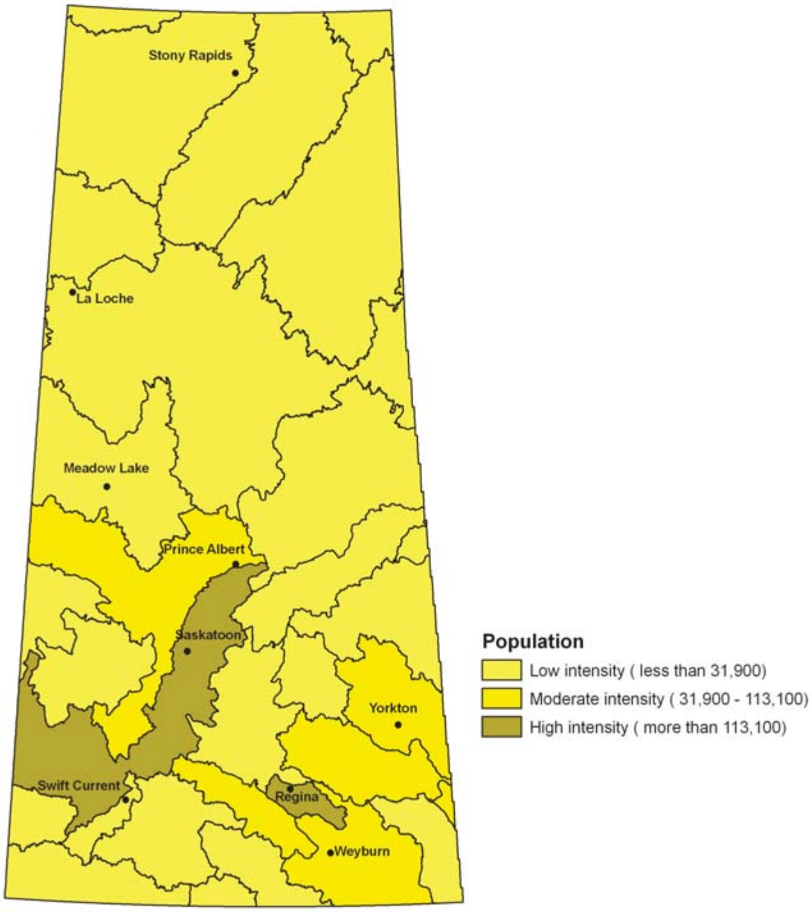

Figure 68. Human population size by watershed for both 2001 and 2006.

Human population size by watershed did not change significantly between 2001 and 2006, so the intensity ratings for each watershed shown in Figure 68 are the same for both 2001 and 2006. Nineteen of Saskatchewan's watersheds are rated as low intensity, five are rated as moderate intensity and two are rated as high intensity (Figure 68). The two high intensity watersheds are the South Saskatchewan River and Wascana Creek Watersheds. The three most populated watersheds are the South Saskatchewan River, Wascana Creek, and North Saskatchewan River Watersheds.

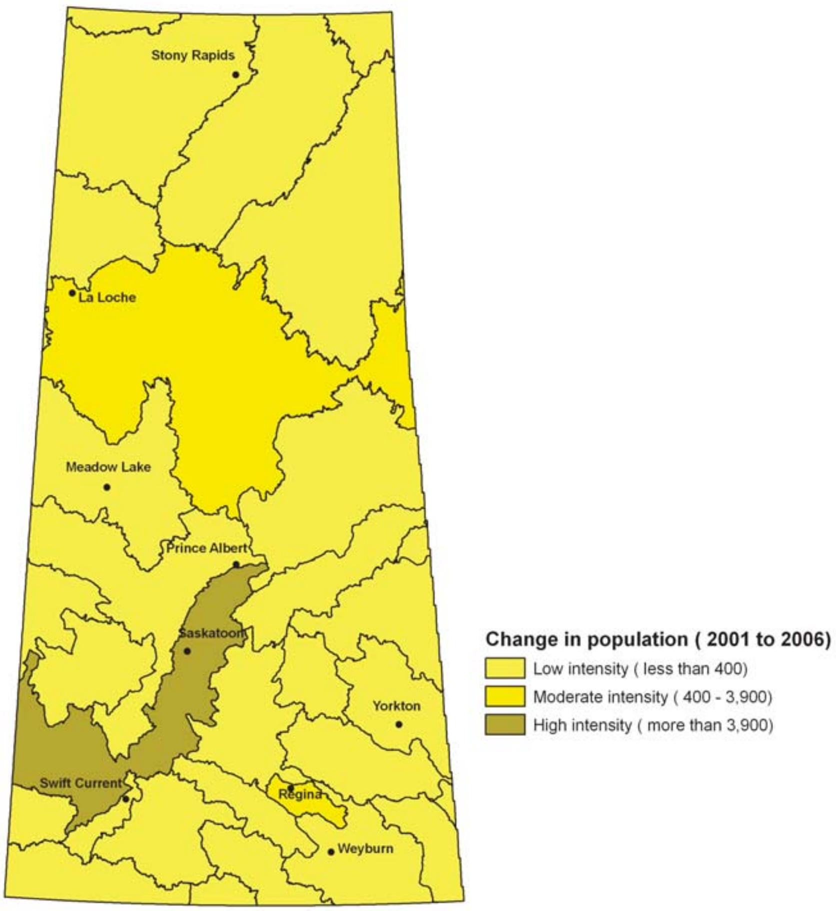

Figure 69. Numerical change in the human population by watershed: 2001-2006.

Figure 69 depicts the numerical change in human population size by watershed between 2001 and 2006. The population of the Churchill River and Wascana Creek Watersheds had a change in population of between 400 and 3,900 people over that five year time period. Population change between 2001 and 2006 was greatest in the South Saskatchewan River and Wascana Creek Watersheds, which increased by 6,334 and 2,719 people, respectively (Figure 69).

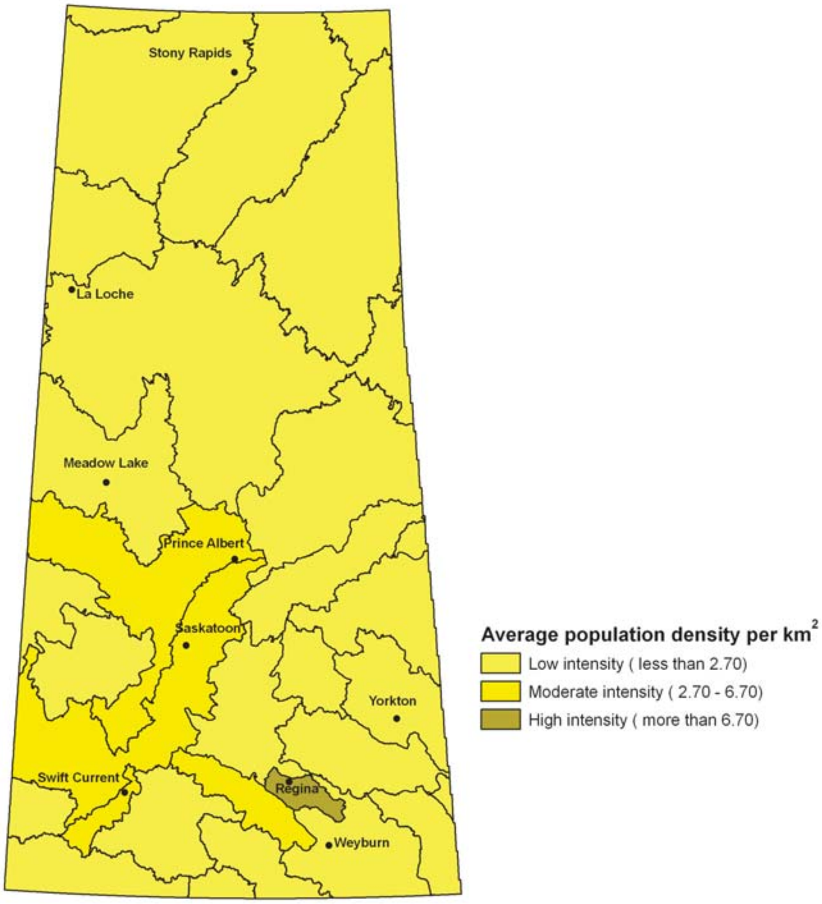

Figure 70. Population density by watershed for both 2001 and 2006.

Figure 70 shows the population density by stressor category for each watershed for both 2001 and 2006. The Wascana Creek Watershed was the most densely populated of Saskatchewan's watershed, with 48.70 people per square kilometre in 2001 and 49.40 people per square kilometre in 2006.

Based on population density, the Wascana Creek, South Saskatchewan River, and North Saskatchewan River Watersheds are the three most stressed watersheds in the province.

Indicator		
Population Size	=	Population within a watershed
Population Change	=	$\frac{\text{Population}_{t1}* - \text{Population}_{t0}**}{\text{Population}_{t0}}$
Population Density	=	$\frac{\text{Population within a watershed}}{\text{Watershed area (km}^2\text{)}}$

*Population_{t1} = population in 2006.
**Population_{t0} = population in 2001.

Rating Scheme
Insufficient data from appropriate scientific studies existed to rate this indicator, so, the Jenks' optimization method was used to find the natural breaks in the data.

Population Size
Low intensity – Population in the watershed is less than 31,900 people.
Moderate intensity – Population in the watershed is between 31,900 and 113,100 people.
High intensity – Population in the watershed is more than 113,100 people.

Numerical Change in Population
Low intensity – Change in population where there are up to 400 people immigrating into the watershed.
Moderate intensity – Change in population where there are between 400 and 3,900 people immigrating into the watershed.
High intensity – Change in population where there are more than 3,900 people immigrating into the watershed.

Population Density
Low intensity – Population density in the watershed is less than 2.70 people/km².
Moderate intensity – Population density in the watershed is between 2.70 and 6.70 people/km².
High intensity – Population density in the watershed is greater than 6.70 people/km².

Data Source: Population data were obtained from the 2001 and 2006 Census of Canada (Statistics Canada 2002, 2007).

Data Handling: This measure requires the Statistics Canada census data by either blocks or Consolidated Census Sub-Division (CCS). Blocks were used to estimate the 2001 population for the following watersheds: Assiniboine River, Big Muddy Creek, Cypress Hills North Slope, Lower Qu'Appelle River, Lower Souris River, Milk River, Moose Jaw River, Old Wives Lake, Swift Current Creek, Upper Souris River, and Wascana Creek Watersheds. The 2001 population for the remaining watersheds was estimated using data from Consolidated Census Sub-Divisions.

Data Discussion: Decadal scales are appropriate for assessing temporal watershed population changes.

Response to the issue

The Government of Saskatchewan is involved in the planning and development of human settlements within the province. The response to this issue takes place through legislation, including *The Planning and Development Act, 1983, The Cities Act*, *The Municipalities Act, The Northern Municipalities Act* and land use planning.

In addition to legislation, there are three associations in Saskatchewan that have been established to assist in community planning:

- the Saskatchewan Association of Rural Municipalities (SARM) has been actively representing all 296 rural municipalities in Saskatchewan since 1905. SARM advocates for rural municipalities and represents them when dealing with senior government officials for issues such as legislation and programs (SARM 2009).
- the Saskatchewan Urban Municipalities Association (SUMA) has been recognized as the collective representative for Saskatchewan's urban municipalities, including cities, towns and villages, since 1906. SUMA ensures urban municipalities are represented in legislation and programs pertaining to urban life in Saskatchewan (SUMA 2009).
- New North - Saskatchewan Association of Northern Communities (SANC) Services Inc. was formed in 1996,. SANC's mission it to represent northern people and communities within the Northern Administration District (NAD) of Saskatchewan, to local, provincial and federal governments (SANC 2009).

Road Density Indicator

This indicator measures the density of roads within each watershed in Saskatchewan.

Indicator	
Road Density	**Status:** Of the roads managed by the Saskatchewan Ministry of Highways and Infrastructure, the length of paved and gravel roads have increased, while the length of roads with granular pavement and thin membrane surface have decreased. The method used to calculate the Roads Density Indicator has been revised from the one used to calculate the Roads Indicator in the 2007 *State of the Watershed Report* (see the **Methods** section on page 24 for details). **Trend:** The density of roads is increasing in Saskatchewan.

The issue

Transportation networks are essential for the distribution of goods and people, and are fundamental to the economic and social development of Saskatchewan. Saskatchewan's total road surface is approximately 160,000 kilometres, including municipal roads and highways. There are 26,398 kilometres of highway in Saskatchewan, including 9,644 km of asphalt concrete pavements, 4,888 km of granular pavements, 5,645 km of thin membrane surface highways, 5,941 km of gravel highways, and 280 km of ice roads (Saskatchewan Ministry of Highways and Infrastructure, 2009).

In 2006, 1,135,636 vehicles were registered in Saskatchewan through Saskatchewan Government Insurance (SGI), with 78.5% of all registered vehicles being private vehicles (SGI 2006). In 2006, approximately 87% of Saskatchewan's population commuted to work by private motorized vehicle, which was above the national average of 80%. The percentage of Saskatchewan residents that took public transit was 2.2%, while the national average was 11%. The percentage of people that took public transit who live in the four largest cities in Saskatchewan (Saskatoon, Regina, Prince Albert, and Moose Jaw) was 3.9%. Sustainable transportation (e.g. bike, public transit, and walk) in Saskatchewan accounted for 11.8% of commuters' mode of transport, versus the national average of 18.7%. The median distance commuted to work in Saskatchewan was 4.5 kilometres, 0.3 kilometres more than 2001. The national median distance travelled to work was 7.6 kilometres. In 2006, 74.4% of Saskatchewan commuters travelled less than 10 kilometres to work (Statistics Canada 2007).

Roads can have physical, chemical, and biological effects on both aquatic and terrestrial ecosystems. Studies have found that roads can impact ecological processes by increasing soil erosion, water runoff, sediment deposition, turbidity, transport of pollutants in runoff, habitat fragmentation, access to areas by recreational users, the potential for the establishment of invasive species, and altering flow regimes and habitat (Forman and Alexander 1998; Angermeier et al. 2004). Forman and Deblinger (2000) found that various ecological effects of roads extend from at least 100 metres to more than 1 kilometre from the road. Traffic volume can also affect aquatic and terrestrial ecosystems. Studies have found that increases in traffic volume are positively correlated with increases in concentrations of heavy metals in adjacent ecosystems (Birch and Scollen 2003; Snowdon and Birch 2004).

Road Density Indicator in Saskatchewan

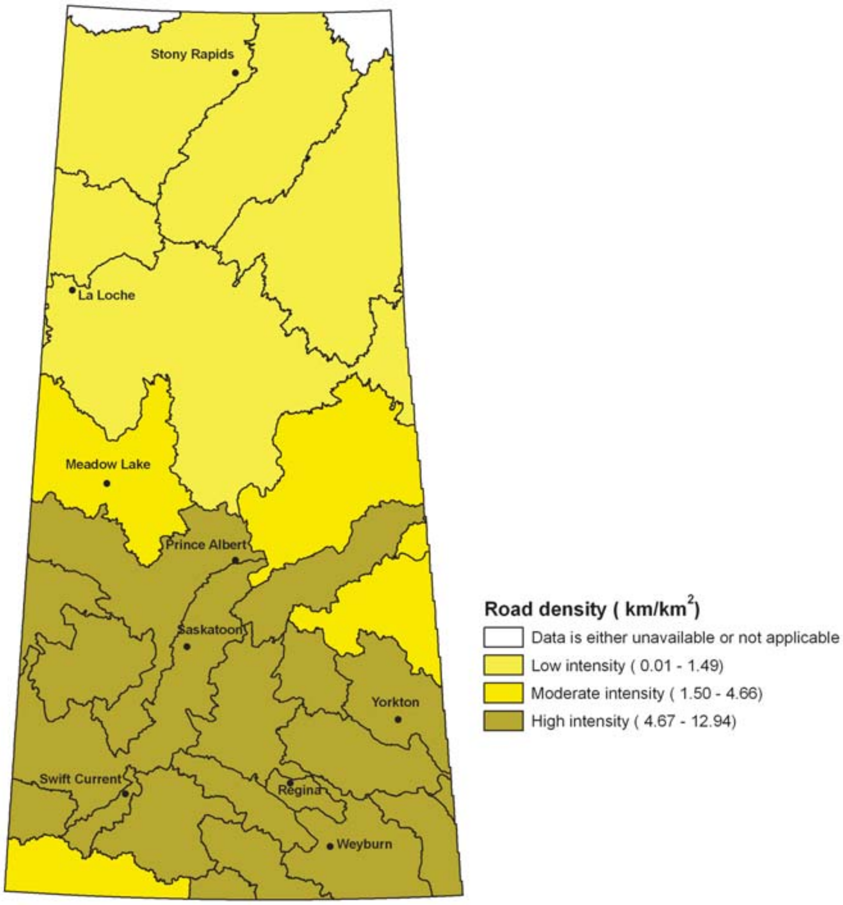

Figure 71. Density of all roads by watershed.

The density of all roads (including highways, grid roads, and rural roads) by watershed is classified as low intensity for five watersheds, moderate intensity for four watersheds, and high intensity for 18 watersheds. The road density within the watersheds that are classified as moderate and high are strongly influenced by rural and other roads, primarily gravel grid roads (Figures 72, 73 and 74).

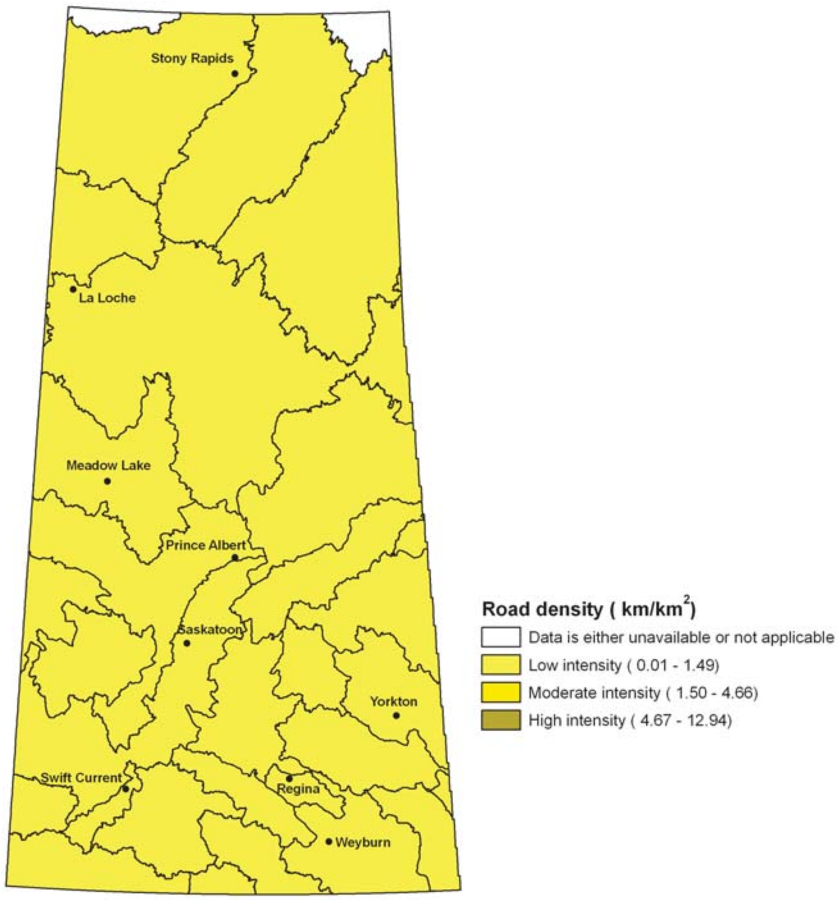

Figure 72. Density of highways by watershed.

The density of highways by watershed is classified as low intensity for all watersheds that have highways (Figure 72).

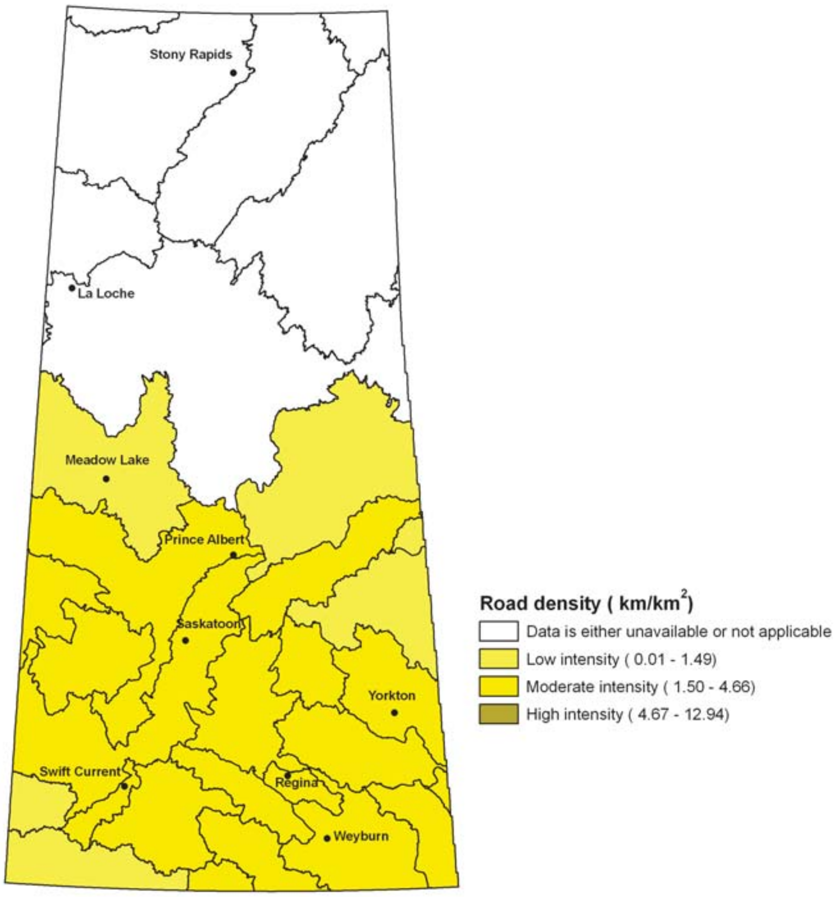

Figure 73. Density of rural roads by watershed.

The density of rural roads is classified for 22 of the 29 watersheds in Saskatchewan. Of these 22 watersheds, five are classified as low intensity and 17 are classified as moderate intensity.

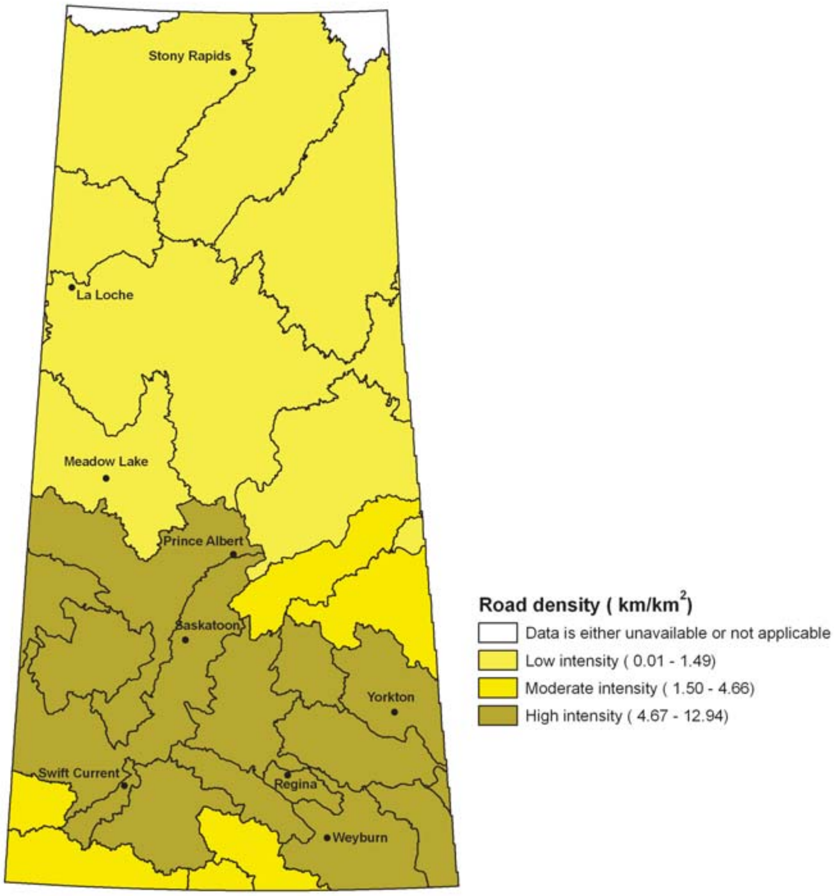

Figure 74. Density of other roads, including grid roads, by watershed.

Density of all other roads, including grid roads, is classified as low intensity for seven watersheds, moderate intensity for six watersheds, and high intensity for 14 watersheds.

Indicator		
Road Density	=	Road length (km) / Total watershed area (km²)

Rating Scheme
Insufficient data from appropriate scientific studies existed to rate this indicator, so, the Jenks' optimization method was used to find natural breaks in the Saskatchewan data.

Road Density
Low intensity: Road density in the watershed is less than 1.50 km/km^2.
Moderate intensity: Road density in the watershed is between 1.50 and 4.66 km/km^2.
High intensity: Road density in the watershed is greater than 4.66 km/km^2.

Methods: The method used to calculate the Road Density Indicator has been revised from the one used to calculate the Roads Indicator in the 2007 *State of the Watershed Report*. In the 2007 *State of the Watershed Report* the Road Effect Zone per watershed was calculated using 300 metre buffers for primary roads and 200 metre buffers for secondary roads. Due to the limited amount of data supporting the widths of the buffers used to calculate the Road Effect Zone in North America (Forman 2000) and the standard use of road density as an indicator for roads, the density of roads by watershed is used in this report as the measure of the impact of roads in Saskatchewan.

Data Source: Road density information for highways, rural roads and other roads was obtained from the Saskatchewan Ministry of Highways and Infrastructure May 2009.

Data Discussion: Insufficient data from appropriate scientific studies existed to create an appropriate rating scheme for this indicator. However, a small number of studies have identified road density thresholds. Road density (road kilometres/square kilometres) is commonly used in the scientific literature. Road densities above certain thresholds have the potential to negatively affect various wildlife species. For example:

- 1.24 km/km² caused grizzly bears to be significantly displaced;
- 1.25 km/km² caused black bears to be significantly displaced;
- 0.62 km/km² adversely affected elk; and
- road densities of less than 0.28 km/km² supported strong bull trout populations. Bull trout populations were found to decrease when the road density was 0.87 km/km² or greater, and bull trout populations are typically absent when road densities are 1.06 km/km² (Hammer 2003 and British Columbia Ministry of Water, Land, and Air Protection 2002).

Response to the issue

The Government of Saskatchewan is involved in the planning and development of roads within the province. The response to this issue takes place through legislation and land use planning. Some of the legislation that controls road development includes *The Highways and Transportation Act, 1997* and *Regulations*, administered by Saskatchewan Ministry of Highways and Infrastructure; and *The Planning and Development Act*, *2007*, administered by the Saskatchewan Ministry of Municipal Affairs (see **Legislative Tools, Strategies, Policies, and Guidelines** in Appendix C).

To assist in the planning of transportation systems in Saskatchewan, the Saskatchewan Ministry of Highways and Infrastructure initiated the development of Area Transportation Planning Committees. The first committee was established in 1995. Committee members include representatives from rural and urban municipalities, Regional Economic Development Authorities, the Saskatchewan Urban Municipalities Association (SUMA), the Saskatchewan Association of Rural Municipalities (SARM), Saskatchewan Ministry of Highways and Infrastructure, and other major stakeholder groups in the area (Saskatchewan Highways and Transportation 2006).

In addition to legislation and land use planning, Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Administration initiated the Prairie Grain Roads Program, which ran from 2001 to 2006. The purpose of the program was to improve grain roads and provincial secondary highways used for the transportation of grain.

Aquatic Fragmentation Indicator

This indicator identifies the aquatic fragmentation of stream segments caused by dams and low-level crossings.

Indicator	
Aquatic Fragmentation	**Status:** Work is currently being done in Saskatchewan to assess the effect aquatic fragmentation is having on aquatic benthic macroinvertebrates and lake sturgeon. The method used to calculate the Aquatic Fragmentation Indicator has been revised from the one used to calculate the Aquatic Fragmentation Indicator in Saskatchewan's 2007 *State of the Watershed Report* (see the **Methods** section on page 27 for details). **Trend:** The number of dams and low-level crossings in Saskatchewan has remained relatively constant over the past 20 years.

The issue
Water control structures such as dams, weirs, drop structures, and other man-made systems which modify hydrologic flow can impact upstream and downstream ecosystems. The potential positive or negative environmental impacts of aquatic fragmentation include changes in habitat and the impediment of the migration and dispersal of aquatic species, which can ultimately result in localized extinction of some freshwater organisms (Dynesius and Nillson 1994; and Gehrke et al. 2002).

Directed research in Saskatchewan assessing the effects of aquatic fragmentation on riverine ecosystems have found the following:

- Mayfly fauna along the South Saskatchewan River were impoverished downstream of the Gardiner Dam, compared to mayfly fauna 10 kilometres upstream of the dam. A suggested possible cause was that the water temperature was 10^0C colder in the outflow of the dam compared to the upstream water temperature (Lehmkuhl 1970).
- In the summer of 2007, the Saskatchewan Watershed Authority initiated a study to further investigate the potential impacts the Gardiner Dam may be having on the South Saskatchewan River ecosystem downstream of the dam. Fifty days of water temperature data collected from mid-June until the end of August suggest that the mean water temperature up to 110 kilometres downstream of Gardiner Dam is significantly colder than the temperature 10 kilometres upstream of the dam (Unpublished Data).

Aquatic Fragmentation Indicator in Saskatchewan

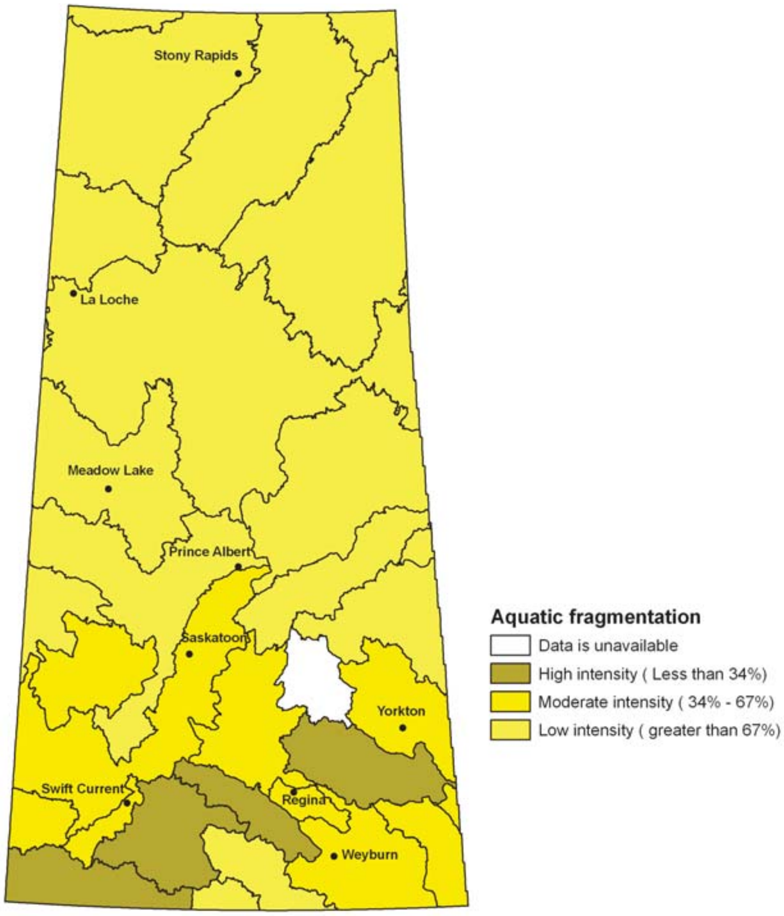

Figure 75. Aquatic fragmentation in the watersheds of Saskatchewan.

Fifteen watersheds have low levels of aquatic fragmentation, nine watersheds have a moderate intensity of aquatic fragmentation, and four watersheds are highly fragmented. The watersheds that are highly fragmented include the Lower Qu'Appelle River, Milk River, Old Wives Lake and Moose Jaw River Watersheds. A highly fragmented watershed is classified as a watershed where less than 34% of the stream segments within its boundaries are unfragmented. There was no data available to calculate aquatic fragmentation in the Quill Lakes Watershed, as the 1:1,000,000 projection of the Saskatchewan Stream Network used to calculate this indicator showed no watercourses within the watershed.

Indicator		
Dam ratio	=	Longest length of stream segments unfragmented by dams / Total length of waterways within watershed
Low-level crossing ratio	=	Longest length of stream segments unfragmented by low-level crossings / Total length of waterways within watershed
Aquatic fragmentation	=	Dam ratio + (0.33 x low-level crossing ratio) / 133

Weighting was used to capture the relative difference in impacts between dams (which are predicted to have the most impact) and low-level crossings.

Rating Scheme
Insufficient data from appropriate scientific studies existed to rate this indicator, so the Jenks' optimization method was used to find the natural breaks in the data.

Aquatic Fragmentation
Low intensity: Proportion of stream segments that are unfragmented is greater than 68%.
Moderate intensity: Proportion of stream segments that are unfragmented is between 34% than 67%.
High intensity: Proportion of stream segments that are unfragmented is less than 34%.

Methods: The method used to calculate the Aquatic Fragmentation Indicator has been revised from the one used to calculate the Aquatic Fragmentation Indicator in the 2007 *State of the Watershed Report*. In the 2007 report, the number of aquatic barriers (including dams, stream road crossings, low-level crossings and bridges) was calculated. In this report, the ratio of the longest length of stream segments unfragmented by dams and low-level crossings within a watershed was used to rate the watersheds.

Data Source: Dam locations are from the National Topographic Database and the land location of the Saskatchewan Watershed Authority's dams. Saskatchewan Ministry of Highways and Infrastructure databases were used to determine the locations of low-level crossings. The length of waterways within each watershed were obtained from the Saskatchewan Stream Network 1:1,000,000.

Data Discussion: To improve our understanding of aquatic fragmentation in Saskatchewan, additional data that should be incorporated into this indicator includes weighting fragmentation by stream order and accounting for dams and low-level crossings that have functional fishways.

Response to the issue
The Saskatchewan Watershed Authority regulates the construction, extension, alteration and operation of any works (e.g. dykes, dams, weirs, floodgates, breakwaters, reservoirs, canals, tunnels, bridges, and culverts) in Saskatchewan under *The Saskatchewan Watershed Authority Act, 2005*. The Saskatchewan Watershed Authority also regulates development along reservoir shorelines under *The Reservoir Development Area Regulations*.

In addition to legislation, habitat enhancement programs have also been initiated in Saskatchewan to reduce the impact of aquatic fragmentation. These programs include:

- A partnership project between Fisheries and Oceans Canada, the Saskatchewan Wildlife Federation, and the Saskatchewan Watershed Authority to assess the biological impacts of identified impediments to fish passage. Once the biological impacts of the impediments have been assessed, plans will be developed to reduce or eliminate those impacts. The primary focus of this project is on fish habitat and improving fish access.
- The Saskatchewan Watershed Authority conducts wildlife habitat assessments on lands surrounding the Rafferty and Alameda reservoirs. These assessments are conducted as mitigation of habitat loss, which was required by both the federal and provincial governments for the federal license to construct the Rafferty and Alameda Dams.

The construction of stream crossings by forestry companies within the commercially forested areas are managed to Forestry Management Area standards and guidelines or to Area Based Term Supply standards and guidelines, where specific conditions apply when constructing or maintaining roads and stream crossings.

In 2008, the Saskatchewan Watershed Authority initiated a risk assessment to investigate the current or potential impact of water control structures on downstream environments. The risk assessment was conducted on 43 of the 45 water control structures that are owned and operated by the Saskatchewan Watershed Authority. Five criteria were used to assess the water control structures:

- impoundment services (captured size and use of structure and reservoir);
- issue scope (captured political and regulatory implications of the structure);
- mitigation opportunities (captured flexibility and potential for change for a structure);
- hydrological impact (captured the impact of the structure on flow over time and space); and
- watershed response (captured potential impact of structure on local ecology, water quality and potential future risk) (Pollock 2008).

In the summer of 2008, to address environmental and ecological concerns related to control structures, the Saskatchewan Watershed Authority initiated a survey of 15 locations along the North, South and Saskatchewan Rivers considered to be valuable foraging areas for lake sturgeon (*Acipenser fulvescens*), and associated fish species (Pollock et al. 2009).

Potential Runoff from Urban Impervious Areas Indicator

The Potential Runoff from Urban Impervious Areas Indicator was designed to identify the intensity of runoff from urban impervious areas by watershed. Impervious surfaces such as roads, parking lots, sidewalks, driveways and roofs prevent precipitation from infiltrating the soil, increasing the volume and velocity of runoff from urban areas.

Indicator	
Potential Runoff from Urban Impervious Areas	**Status:** Eleven watersheds have sufficient data that is appropriate to estimate Potential Runoff from Urban Impervious Areas. The method used to calculate the Potential Runoff from Impervious Areas Indicator has been revised and from the Potential Spring Runoff from Urban Impervious Areas Indicator in the 2007 *State of the Watershed Report* (see the **Methods** section on page 31 for details). **Trend:** There was no change in the estimated runoff as a percentage of annual flow between the ten-year (1998-2002) and five-year (2003-2007) median.

The issue

Runoff from impervious areas can negatively impact the health of watersheds by: 1) increasing the volume and velocity of runoff, causing changes in watershed hydrology; and 2) increasing pollutant loadings, which affects water quality. Possible impacts associated with changes in hydrology include flooding, aquatic habitat degradation and the displacement of aquatic species. Pollutants in stormwater runoff can have harmful effects on drinking water supplies, recreational use and wildlife. Ubiquitous urban stormwater pollutants include sediments, motor oil, nutrients from fertilizers and pet waste, microbes, toxic metals, and various organic compounds such as herbicides and pesticides. Schueler (1994) reviewed studies examining the relationship between urbanization and stream quality. He found that once watersheds have more than ten percent impervious area there is often: 1) an increase in the volume of surface runoff; 2) an alteration of stream banks due to increased flows and erosion; and 3) a decrease in aquatic habitat quality resulting in declines in fish and aquatic insect diversity.

Potential Annual Runoff from Urban Impervious Areas Indicator in Saskatchewan

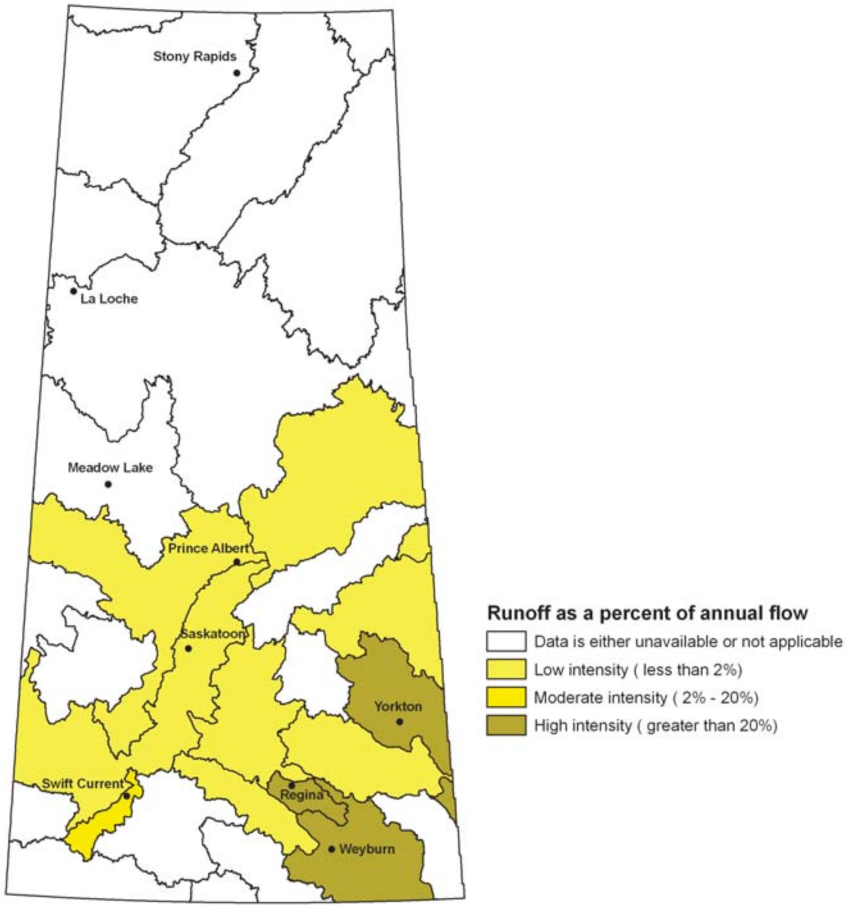

Figure 76. Median runoff from impervious areas as a percent of annual flow: (1998-2002) and (2003-2007).

Median runoff from impervious areas as a percent of annual flow is the same in the 1998-2002 timeframe as it is in the 2003-2007 timeframe for all watersheds (Figure 76). It is estimated that the Assiniboine River, Upper Souris River and Wascana Creek Watersheds have runoff from impervious areas that contributes to greater than 20% of their annual flow. In the Swift Current Creek Watershed, runoff from impervious areas contributes to between 2% and 20% of annual flow.

Urban runoff water quality studies were conducted for the City of Saskatoon during the summers of 2001 and 2002 (Munch and Keller 1985; and McLeod et al. 2004). McLeod et al. (2004) found that concentrations of cadmium, chromium, copper, iron, lead, and zinc in Saskatoon's urban runoff exceeded the Canadian Council of Ministers of the Environment's guidelines for the protection of freshwater aquatic life.

Indicator				
Potential Runoff from Urban Impervious Areas	=	Urban impervious area (m^2)	x	Precipitation (m)
Percentage of Flow Associated with Runoff	=	$\frac{\text{Potential runoff from urban impervious areas}}{\text{Spring flow}}$	x	100

Assumptions:

- All precipitation is effective in producing runoff.
- Observed precipitation at meteorological stations is equal to the precipitation within adjacent urban areas.
- The impervious cover of the major urban cities (>5,000 people) in Saskatchewan was estimated to be 35%, which is a conservative estimate (Perkins 2004).

Rating Scheme

Insufficient data from appropriate scientific studies existed to rate this indicator, so the Jenks' optimization method was used to find natural breaks in the Saskatchewan data.

Potential Runoff From Urban Impervious Areas
Low intensity: Percentage of flow potentially associated with runoff is less than 2%.
Moderate intensity: Percentage of flow potentially associated with runoff is between 2 and 20%.
High intensity: Percentage of flow potentially associated with runoff is greater than 20%.

Methods: In this report, the potential annual runoff from urban impervious areas is calculated. In the 2007 *State of the Watershed Report*, this indicator was calculated using only the potential spring runoff from urban impervious areas.

Data Source: Urban area boundaries were obtained from Information Services Corporation's Cadastral Dataset. Precipitation data were obtained from Environment Canada's online climate data (http:// www.climat.meteo.ec.gc.ca/climateData/canada_e.html). Flow data were obtained from the Water Survey of Canada (http://www.wsc.ec.gc.ca/). Hydrometric flow data used for the calculations of this indicator are from the Water Survey of Canada (2005): Station ID: 05MB001, 05MB003, and 05MD004 (Assiniboine River Watershed), 05LC001 (Lake Winnipegosis Watershed), 05JK007 (Lower Qu'Appelle River Watershed), 05JE006 (Moose Jaw River Watershed), 05EF001 and 05GG 001 (North Saskatchewan River Watershed), 05GG 01 and 05HG001 (Saskatchewan River Watershed), 05HG001 (South Saskatchewan River Watershed), 05HD039 (Swift Current Creek Watershed), 05JF001 (Upper Qu'Appelle River Watershed), 05NB011 (Upper Souris River Watershed), and 05JF005 (Wascana Creek Watershed). All hydrometric flow data are from hydrometric stations downstream of the major urban centres within the watersheds.

Data Handling: The areas of urban centres were multiplied by 0.35, a conservative estimate of imperviousness within these urban centres (Perkins 2004).

Data Quality/Caveats: This land classification is not equivalent to impervious area, but it is correlated and provides the best estimate from available data sources. The percentage of spring flow associated with spring runoff was calculated for eleven of the twenty-nine watersheds. The indicator was not calculated for the remaining eighteen watersheds as either the hydrometric data were unavailable or there were no urban centres that bordered waterways.

Response to the issue
Most aspects of stormwater are currently not specifically regulated under *The Environmental Management and Protection Act, 2002* or *The Water Regulations, 2002* (Saskatchewan Environment 2006c). To address this gap in legislation, the Saskatchewan Ministry of Environment published a Stormwater Guidelines document. The purpose of the guidelines are to provide "technical guidance to municipal authorities, individuals and consultants who plan to develop and implement drainage systems for stormwater in urban/built-up municipal areas, commercial and industrial areas in Saskatchewan" (Saskatchewan Environment 2006c).

In an attempt to further understand runoff within Saskatchewan, the following studies have been initiated:

- In the spring of 2009 a stormwater and snowmelt runoff study, entitled *Stormwater/ Snowmelt Runoff Impact Reduction Initiative for Small Prairie Urban Communities*, was initiated in the City of Yorkton. This study is a partnership project with the Assiniboine Watershed Stewardship Association, the Saskatchewan Watershed Authority, and the City of Yorkton. The objectives of this project are: 1) to gather data on the water quantity and quality from runoff events; 2) to assess existing best management practices to be implemented in the City of Yorkton; and 3) to encourage urban residents to be more environmentally responsible with respect to their impacts on the Assiniboine River.
- At the National Research Council's Centre for Sustainable Infrastructure Research (NRC-CSIR), a research program was established to examine the impact urban stormwater runoff is having on receiving waterbodies. There are currently two monitoring programs underway, and more are planned. In 2008, a rain gauge network, consisting of six sites, was established in the City of Regina to collect rainfall information from May to October of each year. This network was established in collaboration with the City of Regina. Data from this network will be used in conjunction with data from a flow meter network (which will begin operation in the summer of 2010) along the Wascana Creek and its tributaries within the city to analyze how the city's drainage systems respond to different storm events. The data will also be used along with planned sampling of water quality parameters to obtain mass balances of these parameters for the city. NRC-CSIR is collaborating with Environment Canada and the City of Regina on the installation and operation of the flow meter network. Another monitoring program is being planned to look at the impacts of the temperature of urban runoff on the biota in receiving waterbodies.

Municipal Wastewater Effluent Discharge Indicator

This indicator was developed to assess how much of the recorded flow within the watershed can be attributed to wastewater effluent discharge.

Indicator	
Wastewater Effluent Discharge as a Percentage of Recorded Flow	**Status:** Wastewater treatment plants are continuing to be updated and improved as new technology develops. The method used to calculate the Wastewater Effluent Discharge Indicator has been revised from the one used to calculate the Wastewater Effluent Discharge Indicator in the 2007 *State of the Watershed Report* (see the **Methods** section on page 35 for details). **Trend:** Data is currently unavailable to assess trends over time.

The issue
Municipal wastewater effluent is one of the largest sources of point-source pollution to surface water in Canada (Environment Canada 2001, 2004). Wastewater effluent contains a large variety of compounds including various nutrients, pathogens, organic matter and suspended solids. Previous reports have noted around 2,000 identified chemicals known to occur in wastewater, including pharmaceuticals and personal care products (Environment Canada 2001). The ability of ecosystems to process effluent is, in part, dependent on how much effluent there is relative to the volume of the receiving waterbody.

Effluent typically contains high nutrient concentrations, which can lead to the eutrophication of receiving waterbodies. At high concentrations some nutrients can be toxic to aquatic organisms. This is notably the case for ammonia. Saskatchewan's objective for unionized ammonia in surface water is 19 µg/L, which, depending on pH and temperature, can be exceeded downstream of effluent discharges. Smaller receiving waterbodies with low relative flows are at greater risk of eutrophication and/or toxic effects due to the lower dilution and dispersion potential.

Regulated wastewater works in Saskatchewan are listed in the Saskatchewan Ministry of Environment's regulatory records under *The Environmental Management and Protection Act, 2002* within *The Water Regulations, 2002*.

The level of wastewater treatment affects the type and concentration of pollutants in the discharged effluent. The dilution potential of the receiving waters is determined by the volume or flow of that waterway. A watershed with a large water supply has a greater ability to dilute pollutants contained within the effluent than does a watershed with a smaller water supply.

Municipal Wastewater Effluent Discharge Indicator in Saskatchewan

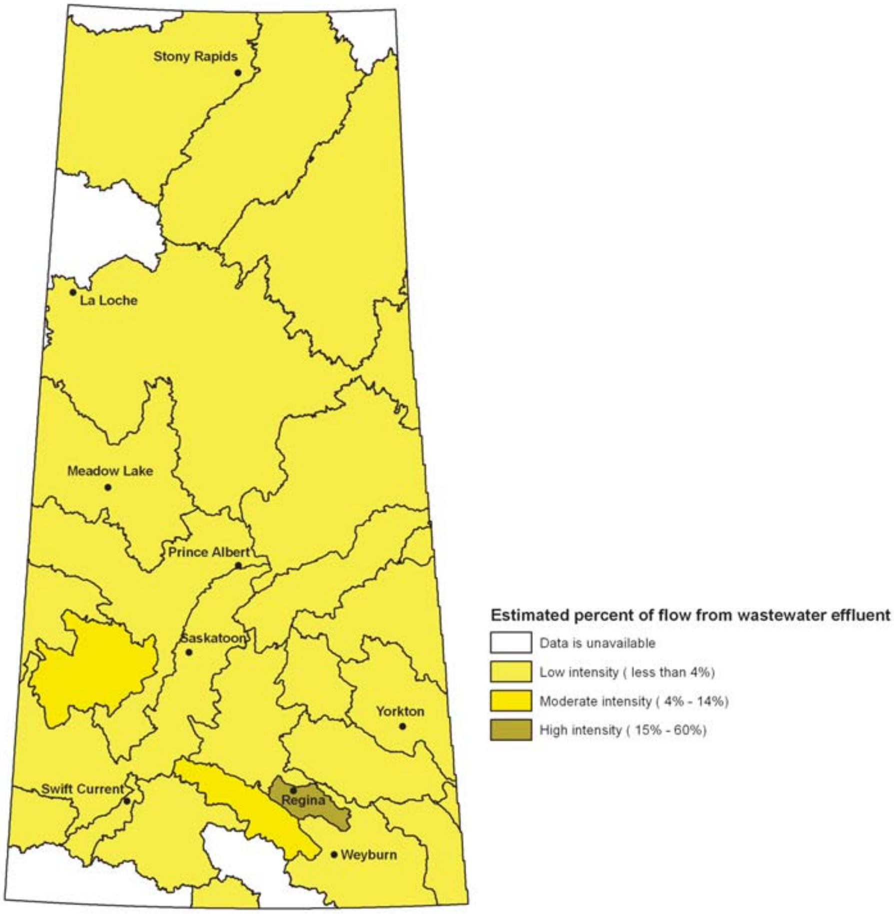

Figure 77. Estimated percentage of recorded flow that can be attributed to wastewater effluent discharge.

Information on the estimated volume of wastewater effluent discharged to surface water is available for 24 of Saskatchewan's 29 watersheds. Of these 24 watersheds, 21 are classified as having low intensity (i.e. less than 4% of the flow within the watershed is from wastewater effluent discharge). The Eagle Creek and Moose Jaw River Watersheds, meanwhile, are classified as moderate intensity, and the Wascana Creek is rated as high intensity.

To mitigate the stress wastewater effluent discharge was placing on the Wascana Creek, Moose Jaw River, and Swift Current Creek Watersheds, communities within these three watersheds have or are in the process of investing in biological nutrient reduction wastewater treatment facilities. Biological nutrient reduction wastewater treatment plants use micro-organisms to reduce organic matter and nutrients (primarily nitrogen, phosphorus and carbon) in the discharged effluent. The City of Regina, in the Wascana Creek Watershed, currently has a tertiary wastewater treatment facility and is evaluating the possibility of upgrading to a biological nutrient reduction plant. The City of Moose Jaw has invested approximately $25 million over the past year in the development of a biological nutrient reduction facility, which is not yet operational. The City of Swift Current, in the Swift Current Creek Watershed has invested roughly $20 million in the past four years in a biological nutrient reduction facility, which is currently operational.

Indicator		
Wastewater Effluent Discharge as a Percentage of Recorded Flow	=	Annual volume of wastewater effluent discharge released to surface water / Average annual recorded flow in watershed

Rating Scheme
Insufficient data from appropriate scientific studies existed to rate this indicator, so the Jenks' optimization method was used to identify the natural breaks in the data.

Wastewater Effluent Discharge as a Percentage of Recorded Flow
Low intensity: less than 4% of the flow in the watershed is from wastewater effluent discharge.
Moderate intensity: between 4% and 14% of the flow in the watershed is from wastewater effluent discharge.
High intensity: more than 14% of the flow in the watershed is from wastewater effluent discharge.

Methods: The method used to calculate the Wastewater Effluent Discharge Indicator has been revised from the one used to calculate the Wastewater Effluent Discharge Indicator in the 2007 *State of the Watershed Report*. In the 2007 Report the dilution potential of a watershed was calculated based on the population relative to the annual surface water supply within the watershed. In this report, the amount of the recorded flow within the watershed that can be attributed to wastewater effluent discharge is used to calculate the indicator.

Data Source: Average annual recorded flow at the watershed level was obtained from the Saskatchewan Watershed Authority. Annual volume of wastewater effluent discharge released to surface water was obtained from the Saskatchewan Ministry of Environment and Indian and Northern Affairs Canada.

Data Discussion: This indicator will eventually report on the percentage of nutrient loading to waterways that can be attributed to municipal wastewater effluent discharge.

Response to the issue
To prevent contamination and eutrophication of waterways, effective wastewater treatment is essential. In Saskatchewan there are 609 licensed municipal wastewater facilities. A municipal wastewater treatment facility is a wastewater treatment plant that uses physical, chemical and/or biological treatment processes to remove contaminants, such as solids, chemicals and other undesirable material, from wastewater and household sewage. Types of sewage treatment include primary, secondary, tertiary, and advanced nutrient reduction.

The Water Regulations, 2002, administered by the Saskatchewan Ministry of Environment under *The Environmental Management and Protection Act, 2002*, regulate the construction, operation and reporting of municipal water treatment and wastewater treatment facilities. Wastewater effluent quality from each of the regulated wastewater works is reviewed and monitored by the Saskatchewan Ministry of Environment.

In rural areas, where municipal sewer systems are impractical, wastewater is treated onsite using private sewage systems. Private sewage systems are regulated by *The Plumbing and Drainage Regulations* and the *Shoreline Pollution Control Regulations, 1976*, administered by the Saskatchewan Ministry of Health through the local Health Region.

In January 2009, the Saskatchewan Ministry of Health released the Saskatchewan Onsite Wastewater Disposal Guide. This guide provides stakeholders in the onsite wastewater industry with design and installation information for private sewage works regulated under *The Plumbing and Drainage Regulations*. The Saskatchewan Onsite Wastewater Disposal Guide is available online at: http://www.health.gov.sk.ca/wastewater-disposal-guide.

In February 2009, the Government of Saskatchewan endorsed the *Canada-wide Strategy for the Management of Municipal Wastewater Effluent*, developed by the Canadian Council of Ministers of the Environment (CCME). The strategy focuses on municipal wastewater facilities which discharge effluent into surface water and that are owned by municipalities, communities, federal and other government entities, and facilities on federal and aboriginal lands. The strategy requires that all facilities achieve minimum National Performance Standards and develop and manage site-specific Effluent Discharge Objectives (Canadian Council of Ministers for the Environment 2009). To learn more about the *Canada-wide Strategy for the Management of Municipal Wastewater Effluent* see: http://www.ccme.ca/assets/pdf/cda_wide_strategy_mwwe_final_e.pdf.

To further reduce the volume and nutrient content of effluent discharges to waterways, 29 communities in Saskatchewan are using effluent irrigation to irrigate forage crops. Effluent irrigation uses treated wastewater, and can be utilized as both a wastewater disposal method and a resource to facilitate economic development.

Landfills Indicator

This indicator was designed to identify the potential risk posed by landfills in Saskatchewan. Two ratings schemes are used: the first assesses the environmental stress landfills place on watersheds in Saskatchewan, and the second assesses the density of landfills by watershed.

Indicator	
Environmental Stress of Landfills	**Status:** The Saskatchewan Ministry of Environment has conducted numerous site inspections and site suitability assessments of the known operational landfill sites over the past three years. The data used to create the Landfills Indicator in the 2007 *State of the Watershed Report* included 509 landfills with a compliance priority classification of "unknown". The data used for this report, in comparison, includes 220 landfills with an "unknown" status. **Trend:** The landfill information gathered through the site inspections and suitability assessments has improved knowledge of the landfills' locations, and improved understanding of the potential environmental stress these landfill locations pose. Through this inspection process, there was an increase in the number of landfills classified as high stress. In the 2007 State *of the Watershed Repo*rt, 59 landfills were classified as a Class A; in this report, 164 landfills are classified as a Class A.
Density of Landfills	**Status:** In 2009, there were 836 municipal landfills in Saskatchewan. **Trend:** The density of all landfills in Saskatchewan has remained stable. However, the number of operational landfills has decreased from 412 to 358 between 2006 and 2009.

The issue
Much of human society's waste materials are disposed of in landfills, and as such landfills represent the cumulative accrual of an enormous variety of products. The major water quality concern from landfills is leachate that percolates through landfills and enters surface or ground water sources. Leachate typically contains organic and inorganic compounds and, depending on the nature of waste deposited in the landfill, may contain toxic substances.

There are an estimated 836 municipal landfill sites in Saskatchewan (Bilokury 2009, Personal Communication). Information provided below is based on a recent reassessment of these landfills performed by the Saskatchewan Ministry of Environment. This revised information was gained through site inspections and site suitability assessments of all the currently known operational landfill sites during the past three years. The purpose of the Saskatchewan Ministry of Environment's reassessment of these sites was to prioritize operational municipal landfills in terms of permitting, and to determine requirements for further investigation, compliance, enforcement and resolution by the department. In conducting the reassessment, no intrusive investigation of on-site soil texture or hydraulic conductivity, or distance to ground water, was conducted; however, distance to surface water was considered as part of the risk ranking of site suitability assessment criteria. In establishing compliance priority classifications for further evaluation and resolution, a number of other factors were examined which influenced the assessment ranking but have no direct bearing on stress to ground water. Rather, these factors consider proximity to surface waters, inhalation receptors, the population served by the landfill, and history of use.

Landfills Indicator in Saskatchewan

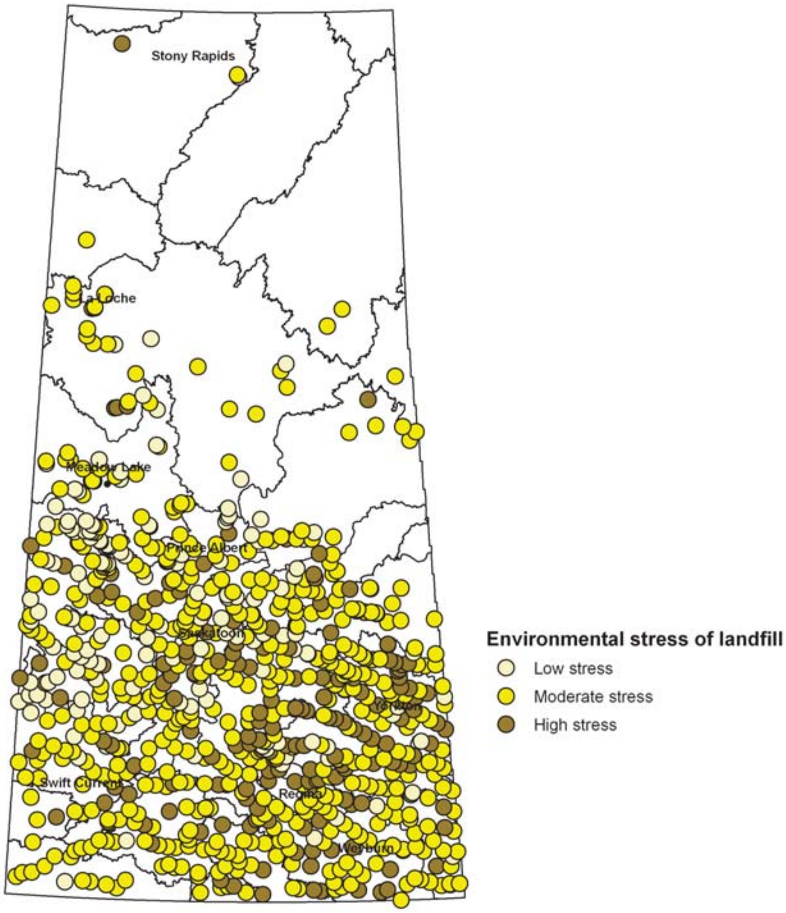

Figure 78. Potential environmental stress of landfills in Saskatchewan.

Of the 836 known municipal landfills sites:

- 358 are currently operating as a waste disposal ground:
- 140 are former waste disposal grounds that have been converted to a transfer station or collection site used to transfer solid waste to a central or regional landfill;
- 157 are only being used by municipalities that now have a street pickup service for temporary storage of designated materials like metals and scrap tires for pickup and recycling;
- 176 are permanently closed and in various states of final decommissioning; and
- 5 have an unknown status.

Based on the Saskatchewan Ministry of Environment's compliance priority classification and the indicator method used in this report, 164 landfills are considered high priority, 305 are considered moderate priority, 144 are considered low priority, and 205 are currently unclassified. The majority of the unclassified sites are closed and/or decommissioned.

The Saskatchewan Ministry of Environment is aware of and/or regulates around 120 sites in northern Saskatchewan and is developing a strategy to assess and achieve compliance with these landfill sites. Currently, limited information is available on these landfills in the northern watersheds to be able to discuss the compliance priority classification or density of landfills in these watersheds.

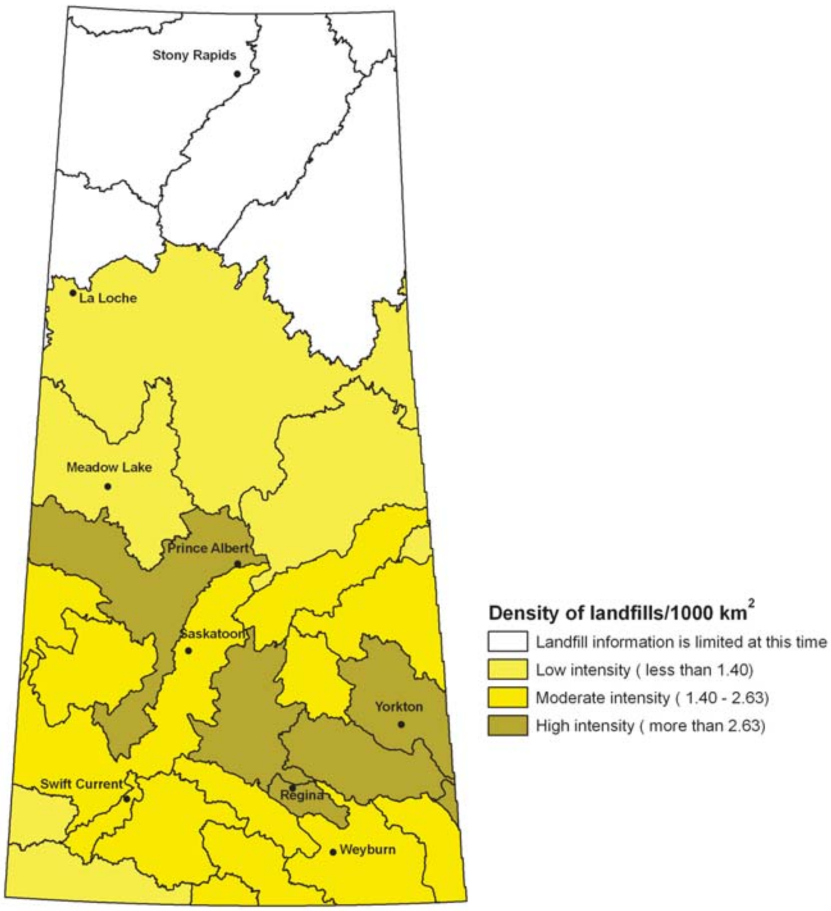

Figure 79. Density of landfills by watershed: 2009.

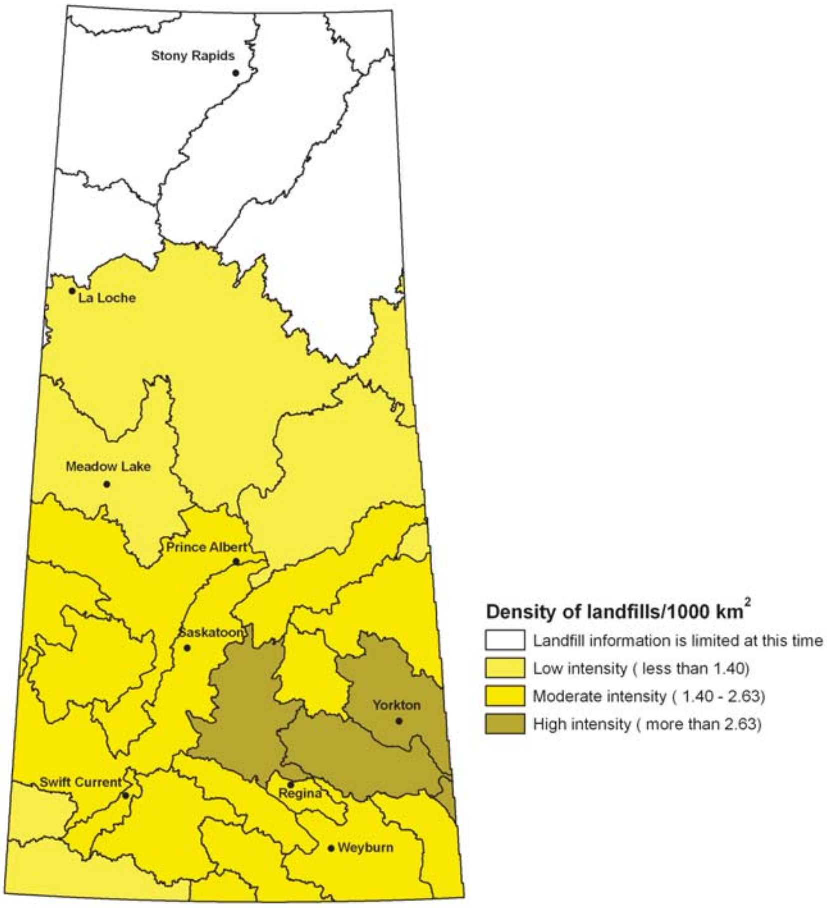

Figure 80. Density of landfills by watershed: 2006.

Relative to all watersheds in Saskatchewan, the density of landfills is greatest in the Assiniboine River, North Saskatchewan River, Upper Qu'Appelle River, Lower Qu'Appelle River and Wascana Creek Watersheds. It should be noted that the density of landfills in the Wascana Creek and the North Saskatchewan River Watersheds increased between 2006 (Figure 80) and 2009 (Figure 79) due to improved knowledge of the landfills in the area, not because of an actual increase in the number of landfills in these watersheds during that timeframe.

Indicator		
Environmental Stress of Landfills	=	Compliance Priority Classification for each landfill
Density of Landfills	=	$\frac{\text{Number of landfills}}{\text{Total watershed area (1,000 km}^2\text{)}}$

Rating Scheme
Insufficient data from appropriate scientific studies existed to rate this indicator, so the Jenks' optimization method was used to identify the natural breaks in the data.

Environmental Stress of Landfills
Low intensity: Landfill is classified as a Class C or low compliance priority.
Moderate intensity: Landfill is classified as a Class B or moderate compliance priority.
High intensity: Landfill is classified as a Class A or high compliance priority (Saskatchewan Environment 1998).

Density of Landfills
Low intensity: Density of landfills is less than 1.40/1,000 km².
Moderate intensity: Density of landfills ranges from 1.40 to 2.63/1,000 km².
High intensity: Density of landfills is greater than 2.63/1,000 km².

Data Source: Data for this indicator were obtained from the Waste Management and Contaminated Sites Unit of the Saskatchewan Ministry of Environment.

Data Handling: The environmental stress classes were weighted using the results of the Saskatchewan Ministry of Environment's landfill site suitability review questionnaire, which is used to assign a compliance priority classification system where: Class A (high compliance priority) = 3; Class B (moderate compliance priority) = 2; and Class C (low compliance priority) = 1. The landfill compliance priority classes were determined based on the following criteria:

- number of people served by the waste disposal site and years in service;
- proximity of the site to residences, highways, surface water, ground water wells and other receptors;
- operational practices at the site and whether it is supervised or not;
- potential for surface or ground water contamination/migration off site;
- hydraulic connection with surrounding aquifers, if known; and
- acceptance of hazardous waste (Saskatchewan Environment 2004-2006 Site Suitability Review).

Data Quality/Caveats: The landfill classification used for this analysis was based on site inspections and site suitability assessments conducted by the Saskatchewan Ministry of Environment's environmental officers. For the majority of the landfill sites the information collected did not include any site-specific hydrogeologic information because this information was not available.

Data Discussion: Assessments of landfill locations and compliance priority classification is ongoing throughout the province.

Response to the issue
The Saskatchewan Ministry of Environment regulates landfills in Saskatchewan through *The Environmental Management and Protection Act, 2002*. This Act regulates and controls the disposal of deleterious substances and activities that are harmful to air, land and water resources. Other legislation involved in municipal landfill management includes *The Municipal Refuse Management Regulations (MRMR); The Litter Control Act and Regulations; The Clean Air Act;* and *The Hazardous Substances and Waste Dangerous Goods Regulations*.

The Municipal Refuse Management Regulations were created in 1986 specifically for the management of the municipal landfill program, which the Saskatchewan Ministry of Environment inherited from the Department of Health in 1984. These regulations, in conjunction with *The Environmental Management and Protection Act, 2002*, regulate and permit municipal landfills in Saskatchewan. More specifically, Section 5 of *The Municipal Refuse Management Regulations* authorizes the establishment, operation or maintenance of a municipal waste disposal ground in accordance with sanitary or modified landfill practices. Further, Section 13 of *The Municipal Refuse Management Regulations* states that Ministerial approval is required for closing a municipal waste disposal ground.

The Saskatchewan Ministry of Environment inspects municipal landfills on a regular basis through its Landfill Delivery Program and strives for compliance and continual improvement of landfill management. The goals of this program are: 1) to improve and develop efficient and effective landfill management; 2) reduce the volume and toxicity of waste entering municipal landfills; 3) deliver education, communication and enforcement vehicles that will ensure public safety, ecosystem health and public support for the program; and 4) implement inspection and permitting programs for landfill operations. These goals are achieved through the department's regulatory and policy framework; encouraging of the development of efficient and practical waste minimization, recycling/stewardship and regional waste systems; and effective communication with and education of the public. Through communication, education, and legislative and policy instruments, the Saskatchewan Ministry of Environment assists communities in managing resources available for the construction, operation and decommissioning of landfills. In 2005-06, the Ministry re-instituted a continual improvement system for landfill management, beginning with a permitting strategy for municipal landfills.

Several key milestones in improving solid waste management in Saskatchewan have been achieved over the past number of years. These successes include a reduction in the number of landfills operating in the province through the establishment of several regional waste management systems, and a reduction in or elimination of garbage being burned at the majority of landfills sites. In addition to this, the Ministry has seen a reduction in the amount of waste going to Saskatchewan landfill sites through the establishment of its province-wide waste stewardship programs for used oil, scrap tires, beverage containers, waste paint, and pesticide containers. A waste electronic equipment program has also been established for personal computers and televisions.

While significant progress has been made in improving solid waste management, there are still several issues/areas where the Saskatchewan Ministry of Environment acknowledges that improvements are required, including:

- The proper management of municipal refuse. Many municipalities are failing to comply with applicable legislation and regulations, and the Ministry is being called upon by the public to increase its compliance and enforcement activities.
- Low commodity prices for recyclable materials are affecting the development and stability of recycling programs. In 2008-09 this resulted in the Province providing $2,000,000 in bridge funding to paper and cardboard recyclers until a long-term Multi-Material Recycling Program is developed which will address paper, plastic, tin and glass.

In order to address these and other issues, the Ministry is developing a comprehensive Solid Waste Management Strategy (SWMS).
The development of the SWMS with public and stakeholder support will create a long-term, comprehensive and affordable approach to resolving the current range of solid waste management issues. Initial consultations were held on a SWMS and now development work by the Saskatchewan Ministry of Environment is taking place (Saskatchewan Environment 2005b, 2005c, 2005d, 2005f). The SWMS will incorporate feedback from stakeholders and the public on the overall development and implementation of the strategy. Improving solid waste management in the province will reduce risk to human health through improved landfill management while developing policies and programs that support residual waste management and waste minimization efforts.

Over the past 20 years, the Saskatchewan Ministry of Environment has made significant progress in dealing with solid waste management issues, including the development of regulations and legislation dealing with proper municipal waste management and the establishment of a number of stewardship programs. The following is a brief description of the Ministry's accomplishments in improving waste management (Saskatchewan Environment 2007):

- The Beverage Container Collection and Recycling Program is authorized under *The Litter Control Act* and *Regulations* and is dedicated to providing a province-wide system to collect and recycle designated non-refillable beverage containers that have been distributed in Saskatchewan. The program is operated by SARCAN, and in the 2007-2008 fiscal year SARCAN collected and recycled approximately 303.7 million designated beverage containers. The overall recovery rate for all non-refillable designated beverage containers is approximately 84.69%.
- The Scrap Tire Management Program is authorized under *The Scrap Tire Management Regulations*. It is an industry stewardship program dedicated to the collection and recycling of tires to mitigate the impacts that scrap tires have on the environment. In 2008, the Saskatchewan Scrap Tire Corporation, which operates the program, collected and recycled over 784,000 tires of all sizes, equivalent to 42 million pounds. Phase Two of the program, the cleanup of scrap tires stockpiled at registered landfills, has removed tires from 28 landfills.
- The Used Oil Material Recycling Program is an industry stewardship program designed to establish a province-wide used oil recycling program that meets *The Used Oil Collection Regulations* and that maximizes the cost-effective collection of oil, filters and containers. In 2008, the Saskatchewan Association for Resource Recovery Corporation collected more than

17.65 million litres of used oil, 1.97 million used oil filters and 330,000 kilograms of oil containers. The program has encouraged the development of over 350 used oil collection facilities in more than 200 communities across the province (Saskatchewan Association for Resource Recovery Corporation 2009).

- The Paint Recycling Program, an industry stewardship program which began in April 2006 under the authority of *The Waste Paint Management Regulations*, is designed to establish a province-wide used paint recycling program. The goal of the program is to reduce the disposal of paint in landfills or sewers and the environmental effects of these disposal practices (Government of Saskatchewan 2006). During the 2007-08 fiscal year, 153,144 containers representing 927,372 pounds of paint were diverted from landfills.
- The Pesticide Container Collection Program is a voluntary program operated by Crop Life Canada Ltd. It was initiated to reduce the environmental impacts that agricultural pesticide containers may have on the environment. In 2007, a total of 1.7 million plastic pesticide containers were collected and recycled.

The Saskatchewan Ministry of Environment has been promoting the development of regional waste management systems since 1992. Regional waste systems offer communities the opportunity to share resources and manpower to provide environmentally-sound waste management for their residents. Today there are a total of thirteen regional waste management authorities in the province serving over 150,000 people, which represents over 15 per cent of the provincial population.

To date, the Province and municipalities have jointly invested over $8 million in regional waste management in Saskatchewan. This investment has assisted in achieving the goals of reducing the amount of waste going into landfills and decreasing the number of landfills in the province that may have the potential to impact the environment (i.e. affecting air quality by burning waste, contamination of ground water from poor landfill location, illegal disposal and littering, etc.). By 2008, 17 regional authorities were servicing approximately 184,000 Saskatchewan residents.

An Advisory Committee consisting of members from the Ministries of Environment and Municipal Affairs have identified issues and suggested recommendations to their respective Ministers which can potentially improve management of municipal water, wastewater and landfill infrastructure in the Northern Saskatchewan Administration District. New North has also completed a feasibility assessment of Regional systems for solid waste management in the Northern Saskatchewan Administration District, for which a $50,000 grant was provided by the Ministry of Environment.

The Ministry of Environment is also developing guidelines for the siting (location), design, operation and monitoring of landfills in the province, which will assist municipalities and other operators in the environmentally-sound management of their waste disposal facilities, in line with Government's approach towards a result-based regulatory framework.

Environmental Assessment Indicator

This indicator was designed to identify the density of environmental assessments and screenings in Saskatchewan by watershed. An increased density of environmental assessments and screenings indicates increased risk to the environment.

Indicator	
Density of Environmental Impact Assessments and Screenings	**Status:** Between 1975 and March 2009, there have been 2,259 screenings and 225 Environmental Impact Assessments that have been or are in the process of being conducted in Saskatchewan. **Trend:** The number of environmental assessments and screenings increased between the two five-year time periods (1998-2002 and 2003-2007).

The issue
Environmental assessment is a decision-making tool that has been used by the Government of Saskatchewan since 1975 to evaluate the ecological, socio-economic and cultural effects of a development before any irreversible decisions are made (Saskatchewan Ministry of Environment 2009). The environmental assessment process is a multi-step decision-making process. The first course of action in the process is when the developer (proponent) of a project which has the potential to impact the environment submits a proposal to the Environmental Assessment Branch of the Saskatchewan Ministry of Environment. The Ministry's staff will then screen this proposal to determine if the project will have a significant impact to the receiving environment. If the project has few or no environmental impacts, it is typically screened out and the project can proceed (with the required licenses and permits). However, if the project is deemed to be a development, an environmental impact assessment is conducted.

A development is defined, according to *The Environmental Assessment Act*, as "any project, operation or activity or any alteration or expansion of any project, operation or activity which is likely to:

- have an effect on any unique, rare or endangered feature of the environment;
- substantially utilize any provincial resource and in so doing preempt the use, or potential use, of that resource for any other purpose;
- cause the emission of any pollutants or create by-products, residue or waste products which require handling and disposal in a manner that is not regulated by any other Act or regulation;
- cause widespread public concern because of potential environmental changes;
- involve a new technology that is concerned with resource utilization and that may induce significant environmental change; or
- have a significant impact on the environment or necessitate a further development which is likely to have a significant impact on the environment" (Government of Saskatchewan 2003).

Environmental Assessment Indicator in Saskatchewan

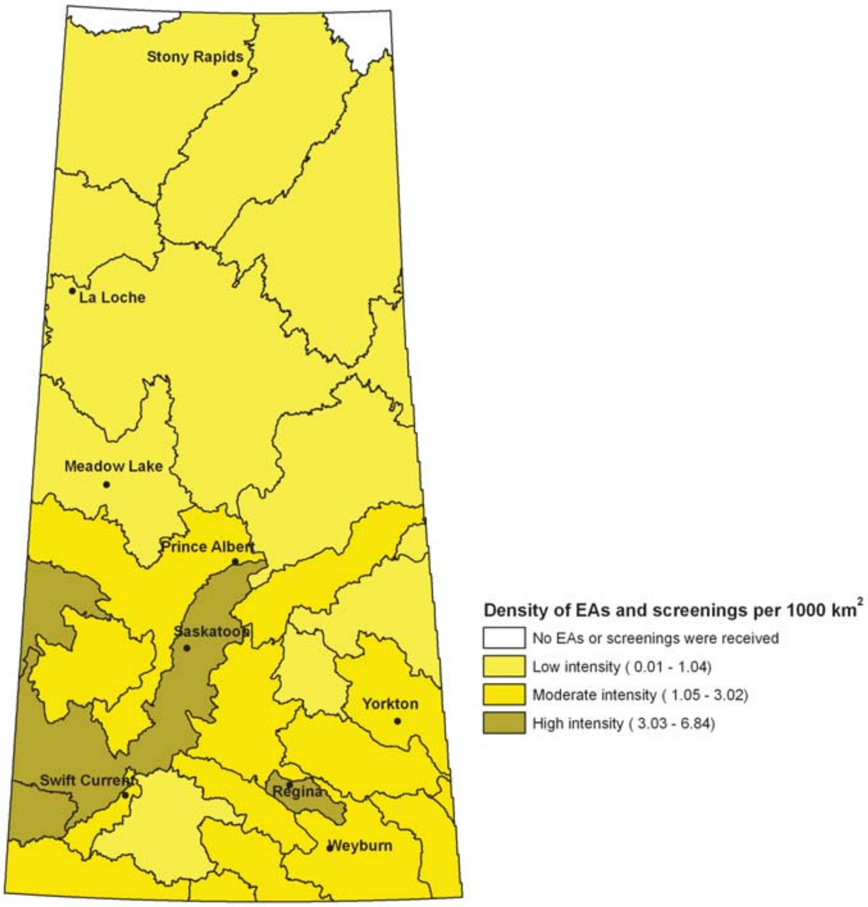

Figure 81. Density of environmental impact assessments and screenings by watershed: 2003-2007.

Between 2003 and 2007, there were 764 project proposals submitted to the Saskatchewan Ministry of Environment that were either screened or triggered an environmental impact assessment. For this time period, the density of environmental assessments and screenings is classified as low intensity for ten watersheds and moderate intensity for 13 watersheds. The Battle River, Cypress Hills North Slope, South Saskatchewan River, and Wascana Creek Watersheds are all classified as high intensity.

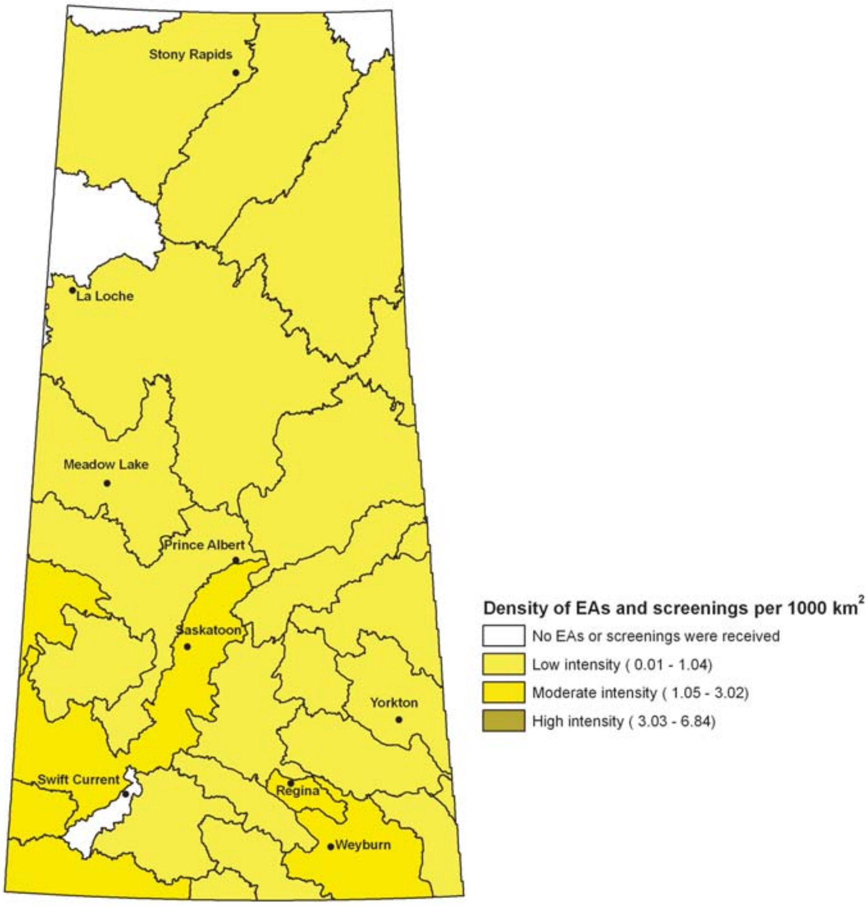

Figure 82. Density of environmental impact assessments and screenings by watershed: 1998-2002.

Between 1998 and 2002, there were 301 project proposals submitted to Saskatchewan Ministry of Environment that were either screened or resulted in environmental impact assessments being conducted. For this five-year period, the density of screenings and environmental assessments is rated as low intensity for 19 watersheds and moderate intensity for six watersheds.

The differences between Figure 81 and 82 include:

- there was an increase in the total number of environmental impact assessments conducted in the province between 1998-2002 and 2003-2007;
- the Swift Current Creek watershed went from zero environmental impact assessments or screenings between 1998 and 2002 to one with moderate intensity in the 2003-2007 period;
- the Assiniboine River, Big Muddy Creek, Carrot River, Eagle Creek, Lower Qu'Appelle River, Lower Souris River, North Saskatchewan River, Moose Jaw River, Poplar River, and Upper Qu'Appelle River Watersheds all went from low intensity in 1998-2002 to moderate intensity in the 2003-2007 period; and
- the Battle River, Cypress Hills North Slope, South Saskatchewan River and Wascana Creek Watersheds changed from moderate intensity in 1998-2002 to high intensity in 2003-2007.

Indicator		
Density of Environmental Impact Assessments and Screenings	=	$\dfrac{\text{Number of Environmental Impact Assessments and screenings}}{\text{Watershed area (1,000 km}^2\text{)}}$

Rating Scheme
Insufficient data from appropriate scientific studies existed to rate this indicator, so the Jenks' optimization method was used to identify the natural breaks in the data.

Density of Environmental Impact Assessments and Screenings
Low intensity: less than 1.05 environmental impact assessments and screenings per 1,000 km^2.
Moderate intensity: between 1.05 and 3.02 environmental impact assessments and screenings per 1,000 km^2.
High intensity: more than 3.02 environmental impact assessments and screenings per 1,000 km^2.

Data Source: The location and type of Saskatchewan projects undergoing screenings and environmental **i**mpact assessments were obtained from the Saskatchewan Ministry of Environment's Environmental Assessment Branch.

Data Quality/Caveats: 1) Of the 2,486 projects submitted between 1998 and 2007, 71 have more than one entry, as they are found in more than one watershed. Therefore, the actual number of Environmental Impact Assessments and screenings used to calculate this indicator may be slightly inflated. 2) Approximately 200 proposals that were submitted between 2002 and 2003 are currently not included in the database used to calculate this indicator.

Response to the issue
The Environmental Assessment Act, administered by the Saskatchewan Ministry of Environment, outlines the environmental assessment and review process any project defined as a "development" must undergo to assess the impact of the development on the environment and to ensure developments in Saskatchewan are sustainable.

In addition to the provincially administered *Environmental Assessment Act*, there is also the federal *Canadian Environmental Assessment Act and Regulations*, regulated by Environment Canada. The *Canadian Environmental Assessment Act* is triggered when the Canadian government is the proponent of the project, provides financial assistance to the project, has an interest in the land where the project will occur, or exercises a regulatory duty.

Invasive Alien Species Indicator

This indicator was designed to identify the stress invasive species are placing on watersheds in Saskatchewan.

Indicator	
Invasive Alien Species	**Status:** Invasive alien species continue to invade Saskatchewan. In 2008, the Saskatchewan Invasive Species Council (SISC) was formed in response to the lack of coordination and understanding associated with invasive species within Saskatchewan. **Trend:** Due to the inaccessibility of data related to invasive species which have been collected by numerous organizations over the years, it is not currently possible to assess trends in invasive species.

The issue
Invasive alien species are non-native species that, due to human intervention, have spread beyond their natural distribution. Invasive alien species are threats to biodiversity and have the potential to alter species composition and the diversity of ecosystems through competition, predation and habitat alteration.

Invasive Alien Species Distribution in Saskatchewan

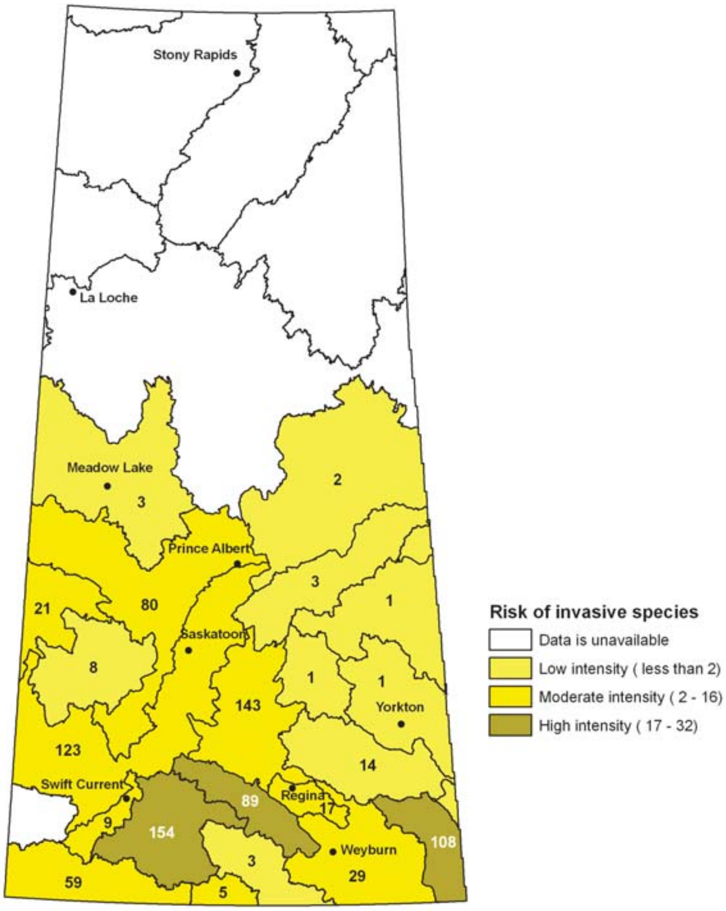

Figure 83. Risk of invasive species by watershed.
Note: the numbers in the watersheds represent the number of invasive plant species occurrences that were reported in the Prairie Region Invasive Plant Species database.

Invasive plant species information was available for 873 locations within 21 watersheds in Saskatchewan. Of these 21 watersheds, nine watersheds are rated as low intensity, nine watersheds are rated as moderate intensity, and three watersheds are rated as high intensity.

Indicator		
Risk of Invasive Species	=	$\frac{\text{Invasive species x NatureServe rank associated with species}}{\text{Watershed area (1,000 km}^2\text{)}}$

Rating Scheme
Insufficient data from appropriate scientific studies existed to rate this indicator, so the Jenks' optimization method was used to find the natural breaks in the data.

Risk of invasive species
Low intensity: Risk of invasive species is less than 2.
Moderate intensity: Risk of invasive species is between 2 and 16.
High intensity: Risk of invasive species is greater than 16.

Data Source: The 873 occurrences of invasive species were downloaded from the Prairie Region Invasive Plant Species (PRIPS) database. NatureServe categorizes invasive species by the impact they have on the natural biodiversity. NatureServe's rankings are based on four criteria: 1) ecological impact, 2) current distribution and abundance, 3) trend in distribution, and 4) management difficulty. For further information about NatureServe see their website at: http://www.natureserve.org/explorer/servlet/NatureServe.

Data Quality/Caveats: In Figure 83, the watersheds with the higher number of invasive species occurrences are often classified in the higher intensity category. This does not necessarily mean that these watersheds have more occurrences of invasive species; it likely means that an invasive species inventory program is in place within these watersheds. The watersheds with fewer occurrences of invasive species are likely under-represented in the data used to develop this indicator.

Response to the issue
In 2004, in response to the threats that invasive species are causing to Canada's ecosystems, the Canadian Food Inspection Agency, in conjunction with federal, provincial and territorial governments, released the document entitled *An Invasive Alien Species Strategy for Canada*. The four main goals of the strategy are to:

- prevent introductions of invasive species;
- detect and identify new invaders;
- respond to invaders in a timely manner; and
- manage invaders effectively (Canadian Food Inspection Agency 2004).

In 2008, the Canadian Food Inspection Agency released a technical report entitled *Invasive Alien Plants in Canada*. This report outlines where invasive plant species are located in Canada; how they were introduced; their economic, environmental and social impacts; and the Canadian programs initiated to respond to the risks of these plants. According to this report, there are between 241 and 360 invasive alien plant species that occur in Saskatchewan (Canadian Food Inspection Agency 2008).

The Saskatchewan Ministry of Agriculture regulates noxious weeds in Saskatchewan through *The Noxious Weeds Act, 1984* and *The Pest Control Act*. *The Noxious Weeds Act, 1984* and *The Pest Control Act* mandate that every owner or occupant of land in Saskatchewan must destroy and prevent the spread of noxious weeds or pest species. To carry out the enforcement component of these Acts, municipalities appoint weed inspectors. *The Noxious Weeds Designation Regulations* lists 41 noxious weeds. Three of the 41 noxious weed species are native to Saskatchewan; therefore, thirty-eight of these of these are considered non-native invasive species. *The Pests Declaration Regulations*, administered by the Saskatchewan Ministry of Agriculture, lists four pests in Saskatchewan:

- the brown or Norway rat [*Rattus norvegicus* (Erxleben)];
- Dutch elm disease, caused by the fungus *Ophiostoma ulmi*;
- grasshoppers; and
- the warble fly.

In addition to legislation, there are also a few programs that have been initiated by the federal and provincial governments to identify and control the distribution of invasive species. Some invasive species initiatives in Saskatchewan include:

- The Saskatchewan Purple Loosestrife and Invasive Species Project was established in 1996 to educate the public on invasive species in Saskatchewan, conduct inventories of invasive species in Saskatchewan, determine the noxious weed status of Saskatchewan, and create and promote eradication and control strategies for the identified invasive species. This program is no longer active.
- The Noxious Weed Management Program, initiated in 1999 by the Government of Saskatchewan to control the spread of noxious weeds such as scentless chamomile, leafy spurge, yellow toadflax and purple loosestrife (Bowes 2003). Noxious weed occurrences within rural municipalities where weed inspectors are appointed are recorded and entered into the Prairie Region Invasive Plant Species (PRIPS) database as part of this program. The PRIPS database was created to keep track of invasive plant species in Manitoba and Saskatchewan. The PRIPS database is a web-based database that allows users to enter information about occurrences of invasive plant species. The objective of the website is to provide information to land owners and managers on invasive species. The location of an invasive plant species can be reported on the PRIPS website at: http://www.crerl.usask.ca/prips/.
- The Shifts in the Distribution, Abundance, Resistance, and Management of Weeds in Prairie Ecosystems Project was initiated in 2001 by Agriculture and Agri-Food Canada in order to conduct weed counts in 4,000 randomly-selected annually cropped fields in Canada's three prairie provinces, gather details on the farm practices of the surveyed fields, and to look for resistant weeds in some of the surveyed fields (Leeson et al. 2003).
- The Saskatchewan Ministry of Environment's strategy to deal with the mountain pine beetle. Some of the key action items in the strategy include:
  - a moratorium restricting the importation of pine forest materials with bark attached into Saskatchewan, implemented in 2002;
  - aerial and ground surveillance in northwest Saskatchewan and the Cypress Hills;
  - developing maps showing the distribution and extent of pine stands at risk;

- ongoing research into the suitability of jack pine as a host, and of the Saskatchewan climate;
- working with the forest industry to develop harvesting plans that help reduce susceptible pine in high-risk areas; and
- ongoing public and stakeholder awareness activities (Government of Saskatchewan 2007a).

In 2008, the Saskatchewan Invasive Species Council (SISC) was formed in response to the lack of coordination and understanding associated with invasive species within Saskatchewan and across Canada. The goals of the Council are:

- to increase the membership and profile of the SISC;
- to increase public awareness regarding the environmental, economic, and societal impacts of invasive species;
- to work with stakeholders on projects related to invasive species; and
- to function as a resource for agencies and stakeholders.

More information about the Saskatchewan Invasive Alien Species Council can be found on their website at: http://www.saskinvasives.ca.

Agricultural Influences

Agricultural activities are widespread and have intensified over time throughout the southern prairies. Cropping practices, livestock grazing, manure application and agricultural inputs can all contribute to non-point source pollution.

An appropriate indicator for assessing non-point source pollution is a general non-point source pollution model. The development of such a model is a priority for State of the Watershed Reporting and for meeting objectives within the Saskatchewan Watershed Authority. However, until such a model is developed, four substitute metrics can be used: Livestock Density, Fertilizer and Pesticide Inputs, Manure Production and Soil Erosion.

At this point, multiple indicators are recommended for capturing the wide range of impacts that agricultural land management practices have on water quality. Ultimately these should be incorporated into a non-point source model.

Livestock Indicator

The Livestock Indicator was designed to identify the intensity of animal production at the watershed scale. Two ratings schemes are employed: one to assess the relative density of livestock among watersheds, and the second to assess the relative risk of livestock operations within 300 metres of a streamcourse.

Indicator	
Density of Livestock	**Status:** The method used to calculate the density of livestock has been revised from the one used to calculate the density of livestock in the 2007 *State of the Watershed Report* (see the **Methods** section on page 61 for details). **Trend:** The density of livestock units increased from 2001 to 2006.
Livestock Operations Within 300 metres of a Streamcourse	**Trend:** The number of livestock operations within 300 metres of a streamcourse decreased between 2001 and 2006. The total number of livestock operations within Saskatchewan decreased by 8.4% between 2001 and 2006.

The issue

The presence of livestock has the potential to impact water quality due to increasing nutrient and pathogen loading associated with increasing livestock numbers. While the number of livestock units present is one factor for assessing potential impact on water quality, the management of livestock is also a critical consideration. Improper management of livestock wastes can contribute to eutrophication of surface water and an increase in the concentration of nitrate in surficial ground water. Diseases from microorganisms found in livestock manure, including bacteria and protists (such as fecal coliforms, *Giardia* and *Cryptosporidium*), are also a concern. These diseases can be contracted by humans through direct contact with or consumption of contaminated water (Miller 2001).
In 2006, there were 3.4 million head of cattle in Saskatchewan, a 16% increase since 2001. Saskatchewan accounted for 21.3% of all cattle and calves in Canada, and 20% of all beef cattle ranching and farming (including feedlots). Approximately 78% of all animal production farming in Saskatchewan can be attributed to beef cattle ranching and farming (including feedlots).

Between 2001 and 2006 , there was a 25% increase in the number of total pigs, a 2% increase in the number of hens and chickens, and an 11% decrease in the number of sheep and lambs in the province (Statistics Canada 2001 and 2006). It should be noted that there has been a reduction of livestock numbers in Saskatchewan since the data were collected for the 2006 Census of Agriculture (Saskatchewan Ministry of Agriculture 2009a).

Livestock Indicator in Saskatchewan

Livestock Density

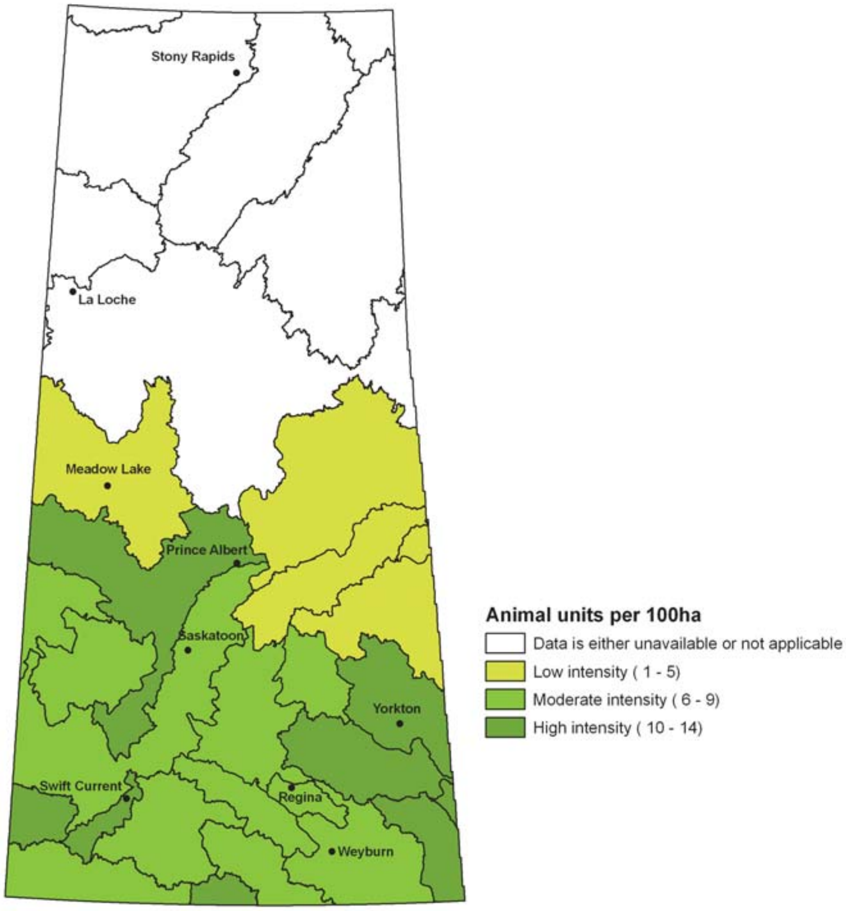

Figure 84. Livestock density by watershed: 2006.

Using 2006 data, four watersheds are classified as having a low density, 11 are classified as having a moderate density and, and seven are classified as having a high density of animal units. In 2006, the density of livestock was highest in the Assiniboine River, Cypress Hills North Slope, Lake Winnipegosis, Lower Souris River, North Saskatchewan River, Poplar River and Swift Current Creek Watersheds.

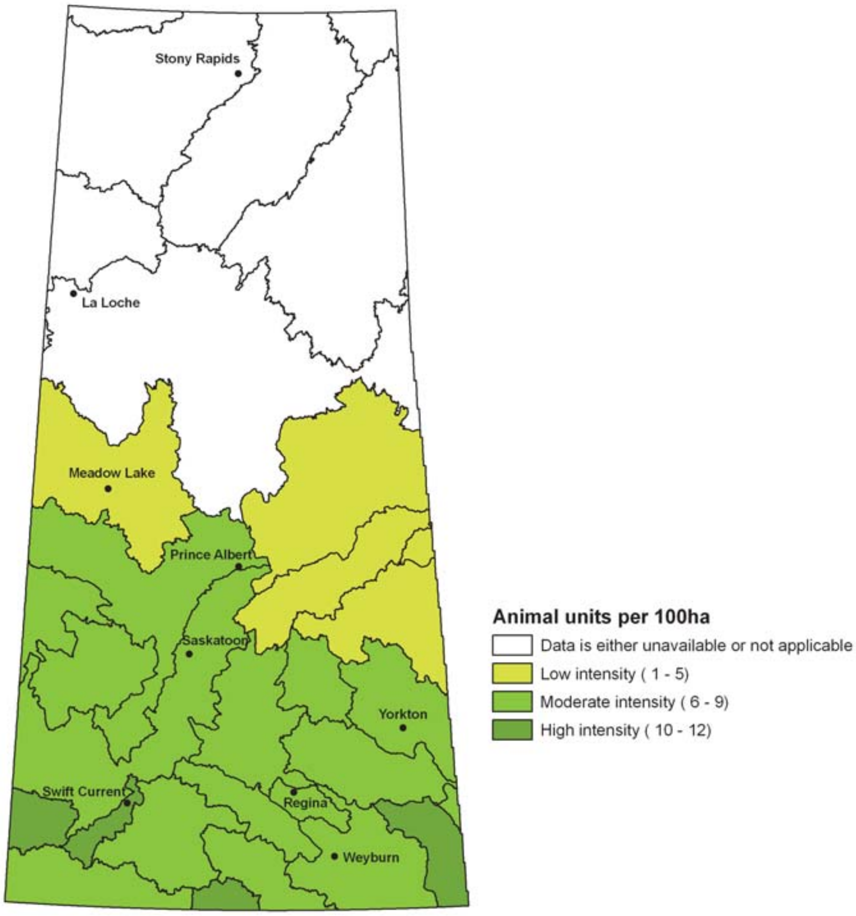

Figure 85. Livestock density by watershed: 2001.

Using 2001 data, four watersheds are rated as low intensity, 14 as moderate intensity and four as high intensity. The four watersheds that had greatest livestock density in 2001 were the Cypress Hills North Slope, Lower Souris River, Poplar River, and Swift Current Creek Watersheds.

In 2006, there was a 17% increase in the number of livestock (animal unit equivalents) compared to the number of livestock in 2001. In both 2001 and 2006, approximately 88% of the livestock units in Saskatchewan were attributed to cattle (Statistics Canada 2001 and 2006).

Livestock Operations

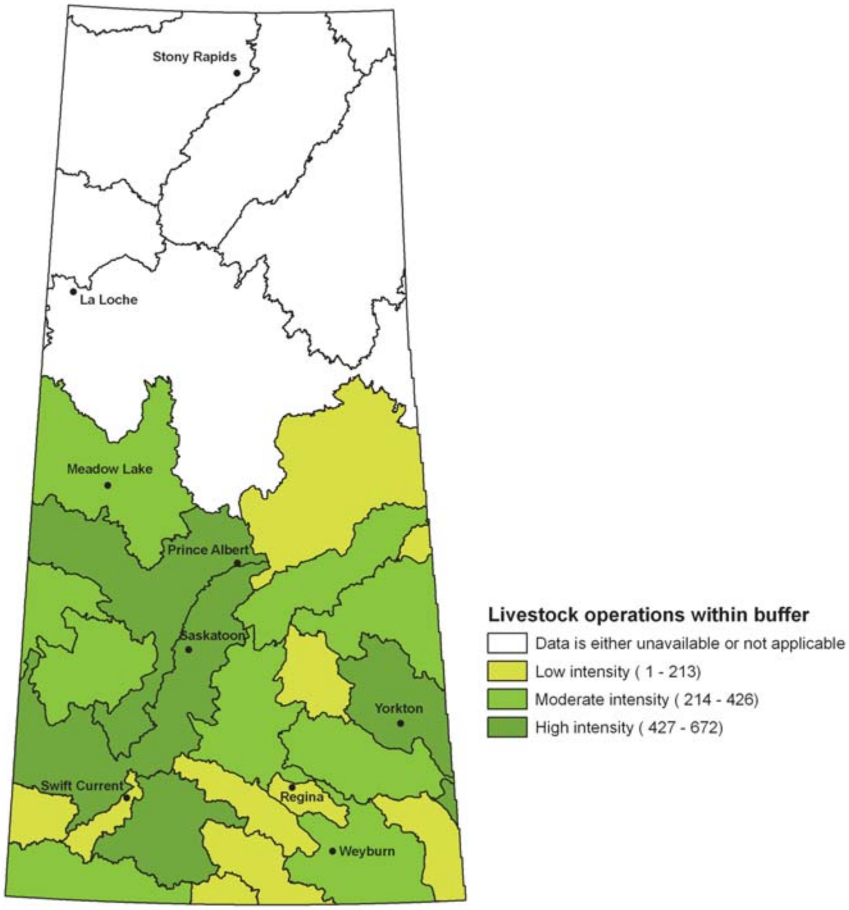

Figure 86. Relative risk of livestock operations within 300 metres of a streamcourse: 2006.

In 2006, the watersheds with the highest intensity of livestock operations within 300 metres of a waterway were the Assiniboine River, North Saskatchewan River, Old Wives Lake and the South Saskatchewan River Watersheds.

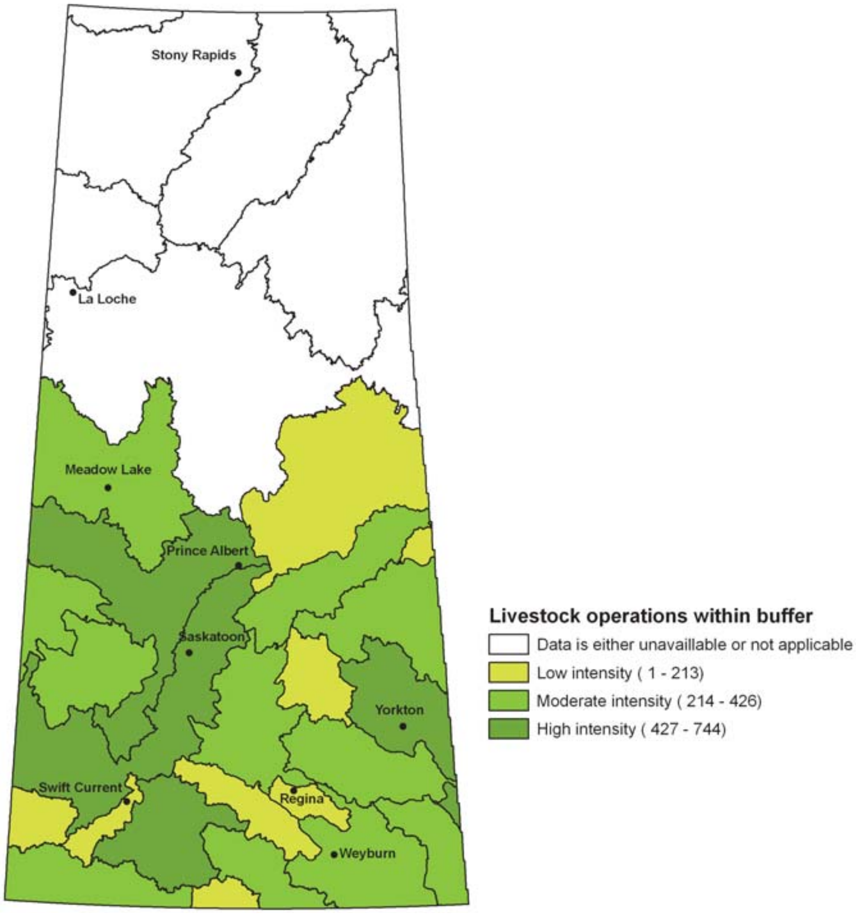

Figure 87. Relative risk of livestock operations within 300 metres of a streamcourse: 2001.

In 2001, the watersheds with the highest intensity of livestock operations within 300 metres of a waterway were the Assiniboine River, North Saskatchewan River, Old Wives Lake and the South Saskatchewan River Watersheds.

In 2006, two watersheds that were classified as moderate intensity in 2001 were reclassified as low intensity. These were the Big Muddy River and Lower Souris River Watersheds. In 2006 there was an 8.4% decrease in the number of livestock operations within Saskatchewan compared to 2001 (Canada 2001 and 2006).

Indicator				
Animal Unit Equivalents (AUE)	=	Livestock population x Animal unit coefficient		
Livestock Density	=	$\frac{\text{Number of livestock (animal unit equivalents) per watershed}}{\text{Total watershed area (ha)}}$		
Livestock Operations Within 300 m of a Streamcourse*	=	$\frac{\text{Watershed area within 300 m of a Streamcourse}}{\text{Total watershed area (km}^2\text{)}}$	x	Number of livestock operations**

Assumptions:

- *Livestock operations have an equal chance of being distributed throughout a watershed.
- *The chance of being located near a watercourse increases with the length of streamcourse in a watershed. This is a conservative assumption; in reality, livestock operations have a tendency to be located closer to streamcourses.
- **The number of livestock operations by watershed is the number of farms within a watershed that reported having livestock.

A livestock operation being located within 300 metres of a streamcourse is one trigger for *The Agricultural Operations Act*, which regulates intensive livestock operations in the province.

Rating Scheme
Insufficient data from appropriate scientific studies existed to rate this indicator, so the Jenks' optimization method was used to find the natural breaks in the data.

Livestock Density
Low intensity: Density of livestock is less than 6 animal unit equivalents per square kilometre.
Moderate intensity: Density of livestock is between 6 and 9 animal unit equivalents per square kilometre.
High intensity: Density of livestock is more than 9 animal unit equivalents per square kilometre.

Livestock Operations Within 300 Metres of a Streamcourse
Low intensity: The estimated number of livestock operations within 300 metres of a streamcourse is less than 214.
Moderate intensity: The estimated number of livestock operations within 300 metres of a streamcourse is between 214 and 426.
High intensity: The estimated number of livestock operations within 300 metres of a streamcourse is greater than 426.

Methods: The method used to calculate the Livestock Density Indicator has been revised from the one used to calculate the Livestock Density Indicator in the 2007 *State of the Watershed Report*. The 2007 *State of the Watershed Report* calculated the livestock density by watershed by dividing the animal unit equivalents by the total watershed area. In this report, livestock density by watershed is calculated by dividing the animal unit equivalents by the total farmed area within a watershed. The method used to calculate the Livestock Operations Indicator in this report is the same as the method used in the 2007 *State of the Watershed Report*.

To improve the accuracy of the data used in these indicators, Statistics Canada ran a customized report to interpolate the 2001 and 2006 Census of Agriculture data from Census polygon-based units to Saskatchewan watershed boundaries. Therefore, the figures associated with the Livestock Density and Livestock Operations indicators in the 2007 *State of the Watershed Report* are not comparable with the figures associated with these same indicators in the 2010 *State of the Watershed Report*. To allow for comparisons to be made between 2001 and 2006 Census of Agriculture data, figures for both indicators and years have been included in this report.

Data Source: The number of livestock and the number of livestock farms reporting within a watershed are from the 2001 and 2006 Census of Agriculture Census Geographic Component databases (Statistics Canada 2001 and 2006). The animal unit equivalents were obtained from a Statistics Canada document entitled *Distribution and Concentration of Canadian Livestock* (Beaulieu et al. 2001). The Saskatchewan Stream Network was used to calculate the watershed area within 300 metres of a streamcourse.

Data Quality/Caveats: To reduce the inaccuracies in buffer placement around lakes caused by the Saskatchewan Stream Network, the lake paths were removed from the stream network.

Response to the issue

Intensive livestock operations are regulated in Saskatchewan by *The Agricultural Operations Act*, which is administered by the Saskatchewan Ministry of Agriculture. The livestock provisions of *The Agricultural Operations Act* require operators to have approved waste storage and management plans that are designed to protect surrounding water resources.

Livestock grazing on provincial forest land is authorized through *The Forest Resources Management Act*. Producers under permit or Term Supply Licence are responsible to follow conditions or range management plans that help conserve provincial forest resources.

To reduce the environmental risk of livestock operations in Saskatchewan, the federal and provincial governments promote Beneficial Management Practices through the Canada-Saskatchewan Farm Stewardship Program. Beneficial Management Practices related to livestock operations include:

- improved manure storage and handling;
- manure treatment;
- manure land application;
- in-barn improvements;
- relocation of livestock confinement and horticultural facilities;
- wintering site management; and
- nutrient management planning.

A number of monitoring programs have been established across the province to assess the impact of intensive livestock operations on water quality. Some of these monitoring programs include:

- The Spring Runoff Water Quality Program, initiated in 1998 by the Saskatchewan Ministry of Agriculture in partnership with the Saskatchewan Ministry of Environment. The purpose of the program is to monitor select intermittent watercourses adjacent to intensive livestock operations and surrounding fields that have been fertilized with manure to investigate the potential impacts on water quality (Saskatchewan Agriculture and Food 2003a).
- The Spirit Creek Watershed Monitoring Project, initiated in 2000 by the Spirit Creek Watershed Monitoring Committee. The purpose of the project is to monitor the environmental effect of intensive livestock operations on soil, water and air quality in the Spirit Creek Watershed, a sub-basin of the Assiniboine River Watershed. In 2006, the Spirit Creek Watershed Monitoring Committee released their Five Year Report. The conclusions of the report were that the intensive livestock operations in the Spirit Creek Watershed were not having a negative impact on the local environment. The committee has recommended that soil/manure monitoring continue until the end of 2012.
- The Saskatchewan Ministry of Agriculture has an ongoing nutrient management project on a feedlot near Rhein, Saskatchewan, to determine the impact of solid manure application on soil and water.

Soil Erosion Indicator

This indicator was designed to identify soil erosion intensity at the watershed scale.

Indicator	
Soil Erosion	**Status:** Information used to develop this indicator was obtained from Agriculture and Agri-Food Canada's *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series*. Currently no new data is available to revise this indicator. **Trend:** Currently, trends in soil erosion at the watershed level cannot be assessed. However, between 1981 and 2001 there was, on average, a decrease in water, wind and tillage erosion in Saskatchewan. The decrease in soil erosion in Saskatchewan during this period has been attributed to a 50% reduction in summerfallow area and an increase in the adoption of direct-seeding technologies (Lefebvre et al. 2005).

The issue

Soil erosion can be an important contributor to agricultural non-point source pollution. Sediment from soil erosion that enters surface waters can increase nutrient loading, decrease water transparency, and increase areas of sediment deposition, which can in turn affect the quality of aquatic habitat. Sediment can enter surface water by several different pathways, including wind erosion, overland flow and from degraded riparian areas. Much of the soil lost to wind and overland flow is redistributed on land; however, increased risk of soil erosion does increase the risk of it entering surface waters.

Soil Erosion Indicator in Saskatchewan

The information used to calculate this indicator was obtained from the *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series – Report #2* (Lefebvre et al. 2005).

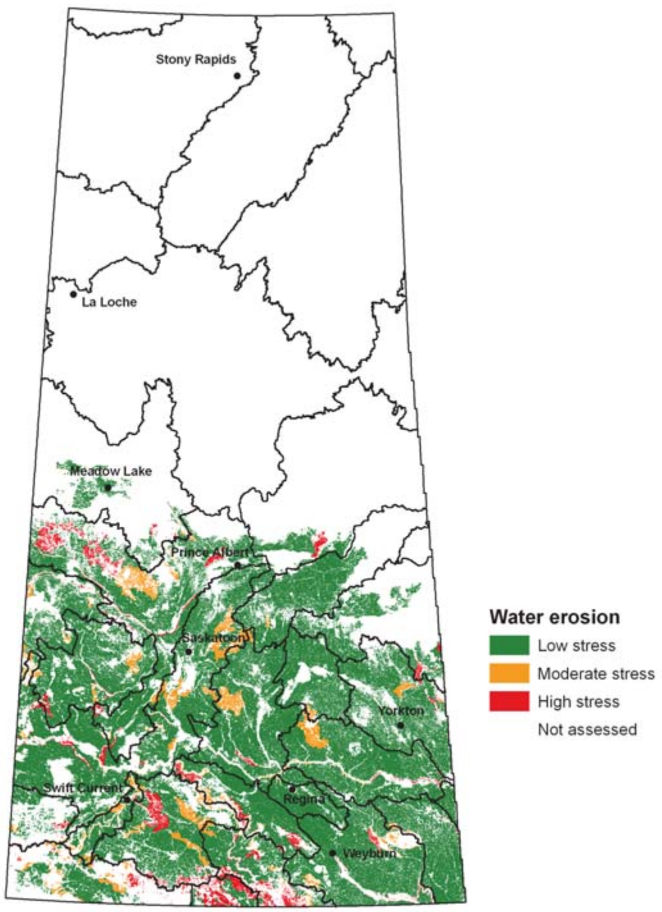

Figure 88. Water erosion risk of annually cultivated soils on a soil landscape basis, with the watershed boundary overlay.

Data Source: van Vliet et al. 2005.

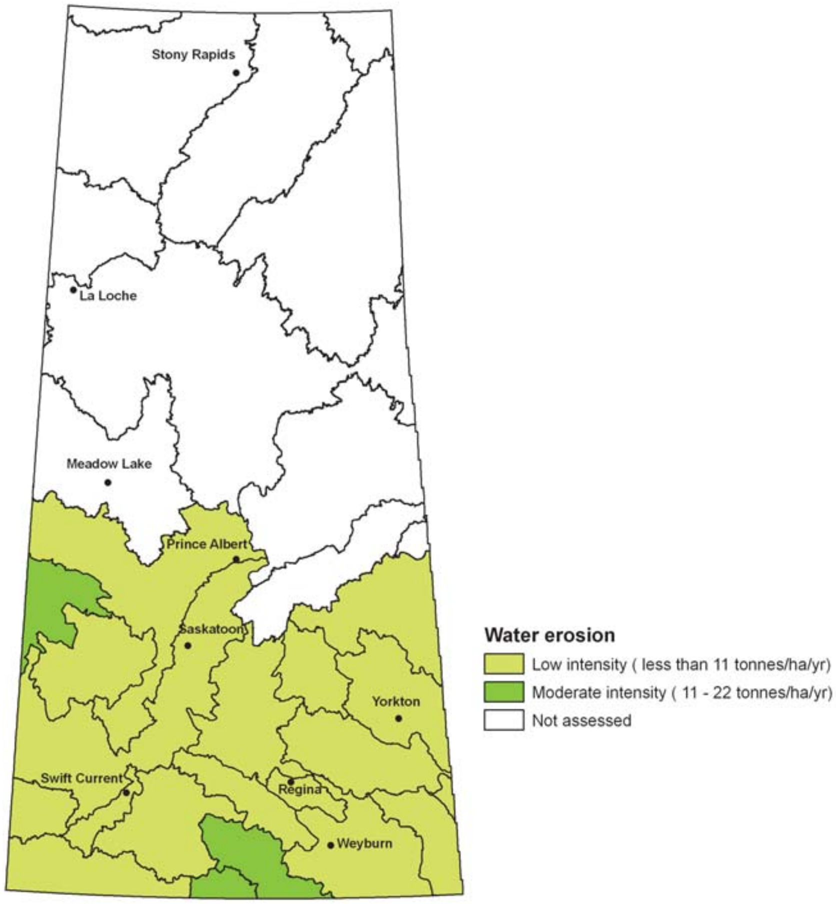

Figure 89. Water erosion intensity of annually cultivated soils by watershed: 2001.
Data Source: van Vliet et al. 2005.

Of the land assessed for water erosion, 92% is categorized in this report as low risk, 3% as moderate risk, and 3% as high risk (van Vliet et al. 2005). Agricultural land in the Beaver River, Big Muddy Creek and Poplar River Watersheds have, on average, moderate risk for water erosion. All other Saskatchewan watersheds that were assessed have, on average, low risk for water erosion.

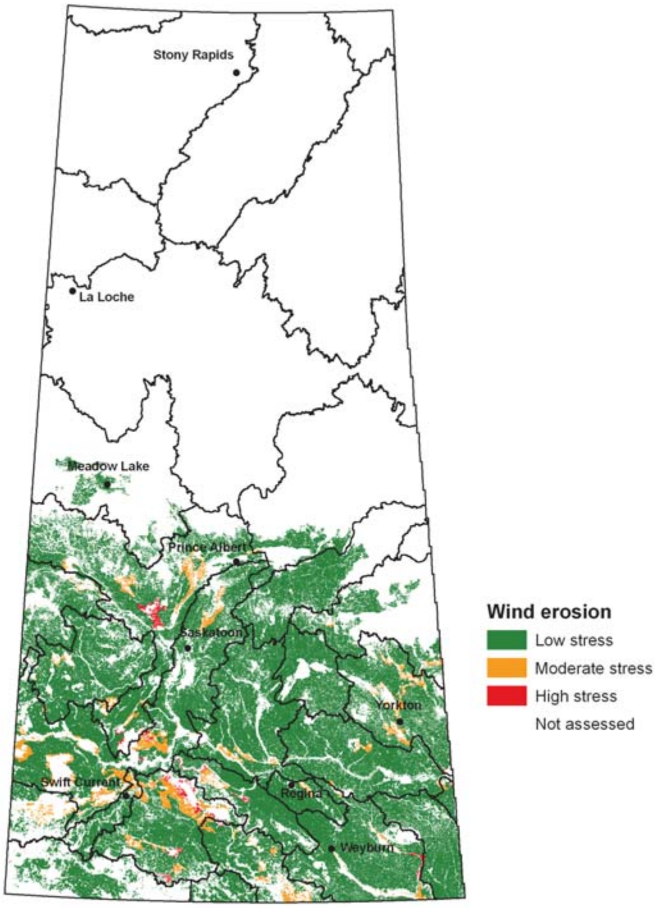

Figure 90. Wind erosion risk of annually cultivated soils on a soil landscape basis, with the watershed boundary overlay.
Data Source: Rostad and Padbury 2005.

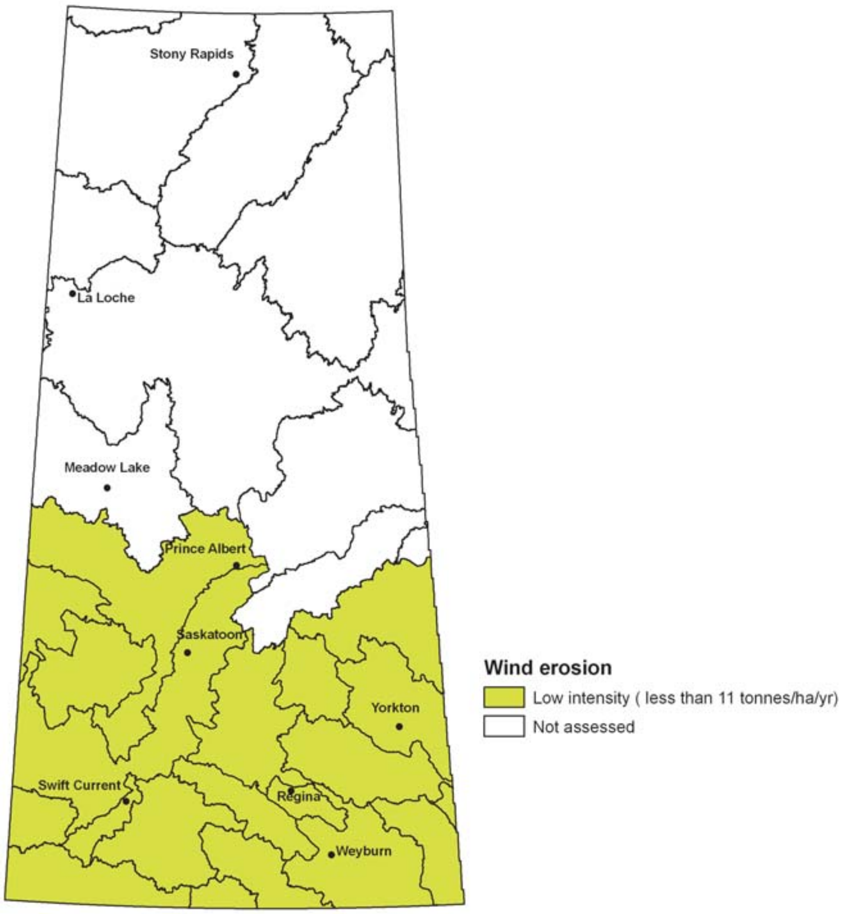

Figure 91. Wind erosion intensity of annually cultivated soils by watershed: 2001.
Data Source: Rostad and Padbury 2005.

Of the land assessed for wind erosion, 88% is categorized in this report as low risk, 7% as moderate risk, and 5% as high risk (Rostad and Padbury 2005). Agricultural land in the watersheds in which assessments were conducted has, on average, low risk for wind erosion.

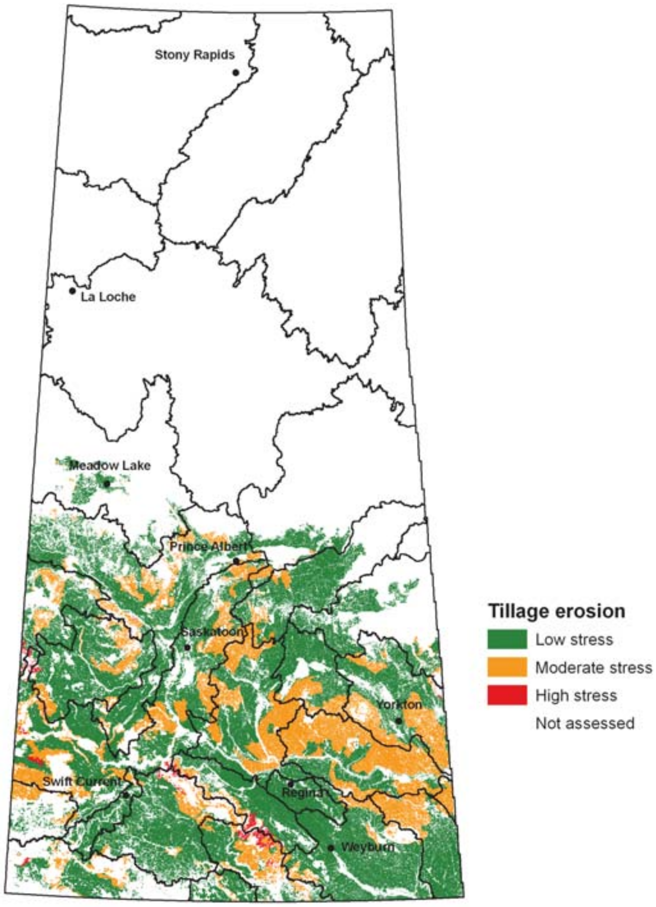

Figure 92. Tillage erosion risk of annually cultivated soils on a soil landscape basis, with the watershed boundary overlay.
Data Source: Lobb 2005.

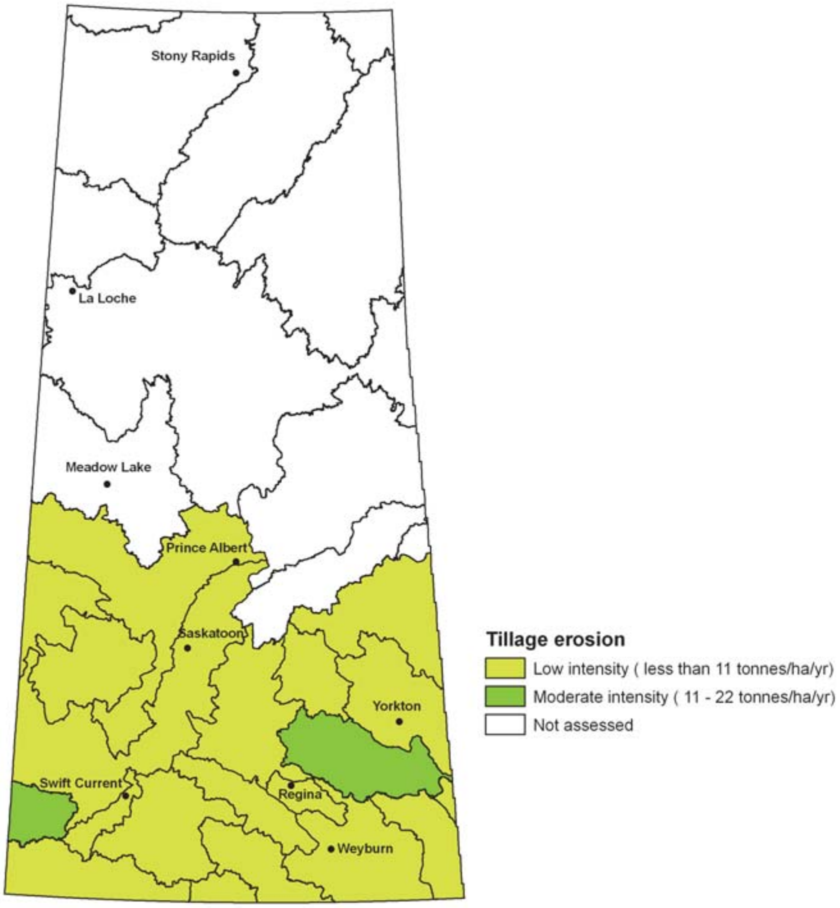

Figure 93. Tillage erosion intensity of annually cultivated soils by watershed: 2001.
Data Source: Lobb 2005.

Of the land assessed for tillage erosion, 72% is categorized in this report as low risk, 27% as moderate risk, and 1% as high risk (Lobb 2005). Agricultural land in the Cypress Hills North Slope and Upper Qu'Appelle River Watersheds has, on average, moderate risk for tillage erosion. All other Saskatchewan watersheds in which assessments were conducted have, on average, low risk for tillage erosion.

Indicator
Three models can be used to calculate soil loss: the Revised Universal Soil Loss Equation - For Application in Canada (RUSLE-FAC), the Wind Erosion Equation (WEQ) and the Tillage Erosion Risk Indicator (TillERI) model.

The RUSLE-FAC is a soil erosion model that predicts long-term average potential soil loss risk caused by rainfall and runoff.

RUSLE-FAC: **A = R x K x L x S x C x P**

where:
A = Estimated erosion in tons per acre per year
R = Rainfall erosivity factor (the amount and intensity of rainfall an area receives)
K = Soil erodibility factor (calculated using several physical soil properties including texture, organic matter, infiltration rate and structure)
L = Slope length factor
S = Slope steepness factor
C = Cover and management factor
P = Support practice factor [practices used for erosion control (contours, terraces, strip cropping)]

The WEQ is a model that predicts soil loss caused by wind.

WEQ: E = f (I, K, C, L, V)

where:
E = Estimated erosion in tons per acre per year
f = Function of ( )
I = Erodibility factor (e.g. texture and aggregation)
K = Surface roughness factor (e.g. ridges)
C = Climate factor
L = Unsheltered length of field factor (i.e. how open the field is)
V = Vegetative cover factor (i.e. cover type, density, etc.)

The TillERI is a model that predicts soil loss risk caused by tillage.

ATE = ET * EL

where:
ATE = Rate of soil loss by tillage erosion (t ha^{-1} yr^{-1})
ET = Tillage erosivity (t $\%^{-1}$ m^{-1} yr^{-1})
EL = Landscape erodibility (% m ha^{-1})

Soil erosion classes were developed for crop productivity purposes, not water quality concerns. The criteria for defining tolerance limits for the purpose of preventing or reducing damage to offsite water quality may be distinct from those tolerances designed to preserve cropland productivity (Renard et al. 1997).

Rating Scheme
The rating system from Wall et al. (2002) has been revised to conform to the categories used for the stressor indicators in this document.

Soil Erosion
Low intensity: Soil erosion is less than 11 tonnes/hectare/year.
Moderate intensity: Soil erosion is between 11 and 22 tonnes/hectare/year.
High intensity: Soil erosion is greater than 22 tonnes/hectare/year.

Data Source: The water, wind and tillage erosion information used to calculate this indicator was obtained from *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series – Report #2* (Lefebvre et al. 2005). The land cover data are from the Southern Digital Land Cover classification of 1993-1994 LANDSAT-TM.

Data Handling: The calculation methods for water, wind and tillage erosion can be found in *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series – Report #2* (Lefebvre et al. 2005). Soil erosion estimates are at a 1:1,000,000 scale, utilizing Soil Landscape of Canada polygons. Soil erosion calculations are only for the annually cultivated area of a Soil Landscape of Canada polygon.

Average soil erosion by watershed was calculated using a weighted average where the percent of the watershed in each of the three risk classes was multiplied by an erosion risk rate. The erosion risk rates used were: low risk areas = 5.5 tonnes/ha/yr; moderate risk areas = 16.5 tonnes/ha/yr; and high risk areas=22 tonnes/ha/yr.

Data Discussion: Temporal analysis can take place on a five-year basis as determined by the Census of Agriculture.

Response to the issue
Sediment deposition caused by soil erosion can impact surface water quality and aquatic habitat. Surface water quality is protected under the Interim Surface Water Quality Objectives (Saskatchewan Environment 2006a). The *Fisheries Act* protects fish habitat from the deposition of deleterious substances such as sediment.

Agricultural Beneficial Management Practices that can reduce soil erosion, as outlined in the guide to the Canada-Saskatchewan Farm Stewardship Program (CSFSP) include:

- riparian area management;
- erosion control structures;
- land management for soils at risk;
- cover crops;
- improved cropping systems;
- shelterbelt establishment; and
- soil erosion control planning.

The move away from conventional tillage to minimum and zero tillage practices and the reduced use of summerfallow are two other agricultural Beneficial Management Practices that have reduced the risk of soil erosion in Saskatchewan caused by water, wind and tillage.

The Saskatchewan Soil Conservation Association has also developed a number of soil factsheets related to direct seeding, including:

- *Getting Started in Direct Seeding*;
- *Economics of Direct Seeding*;
- *Seeding Equipment*;
- *Crop Rotations*;
- *Fertility Management*;
- *Producer Profiles*;
- *Residue Management*; and
- *Weed Control*.

These fact sheets can be found on the Saskatchewan Soil Conservation Association's website at: http://www.ssca.ca/agronomics/index.html.

Fertilizer Inputs Indicator

The Fertilizer Inputs indicator was designed to identify fertilizer use intensity at the watershed scale.

Indicator	
Fertilizer Inputs (kg N/ha)	**Status:** The method used to calculate the Fertilizer Inputs Indicator has been revised from the one used to calculate the Fertilizer Inputs Indicator in the 2007 *State of the Watershed Report* (see the **Methods** section on page 78 for details). **Trend:** Data from 2001 and 2006 Census of Agriculture (CGC database) indicates that there was an increase in the application of nitrogen within Saskatchewan between 2001 and 2006.
Fertilizer Inputs (kg P/ha)	**Status:** The method used to calculate the Fertilizer Inputs Indicator has been revised from the one used to calculate the Fertilizer Inputs Indicator in the 2007 *State of the Watershed Report* (see the **Methods** section on page 78 for details). **Trend:** Data from 2001 and 2006 Census of Agriculture (CGC database) indicates that there was an increase in the application of phosphorus fertilizer between 2001 and 2006.

The issue

Adding more nutrients to surface waters due to human activities increases the risk of cultural eutrophication. Non-point nutrient contributions from agriculture are a known contributor of nutrients to water (e.g. Carpenter et al. 1998). While nutrients are needed to maintain soil fertility and increase crop yield, the concentrations required for agriculture are much greater than those which contribute to cultural eutrophication (Sharpley et al. 2003). In addition, the areal extent of agricultural land is typically greater than that of surface waters. Therefore, without proper management there is the potential that the movement of agronomically insignificant amounts of nutrients can result in a significant ecological change in surface waters.

This indicator is therefore designed to assess the potential risk to surface waters by assessing the intensity of synthetic commercial fertilizer use in Saskatchewan watersheds. The major nutrients in synthetic fertilizer are nitrogen, phosphorus and potassium. However, because of the above-noted impact nitrogen and phosphorus can have on surface waters, this indicator focuses on nitrogen and phosphorus.

Fertilizer Inputs Indicator in Saskatchewan

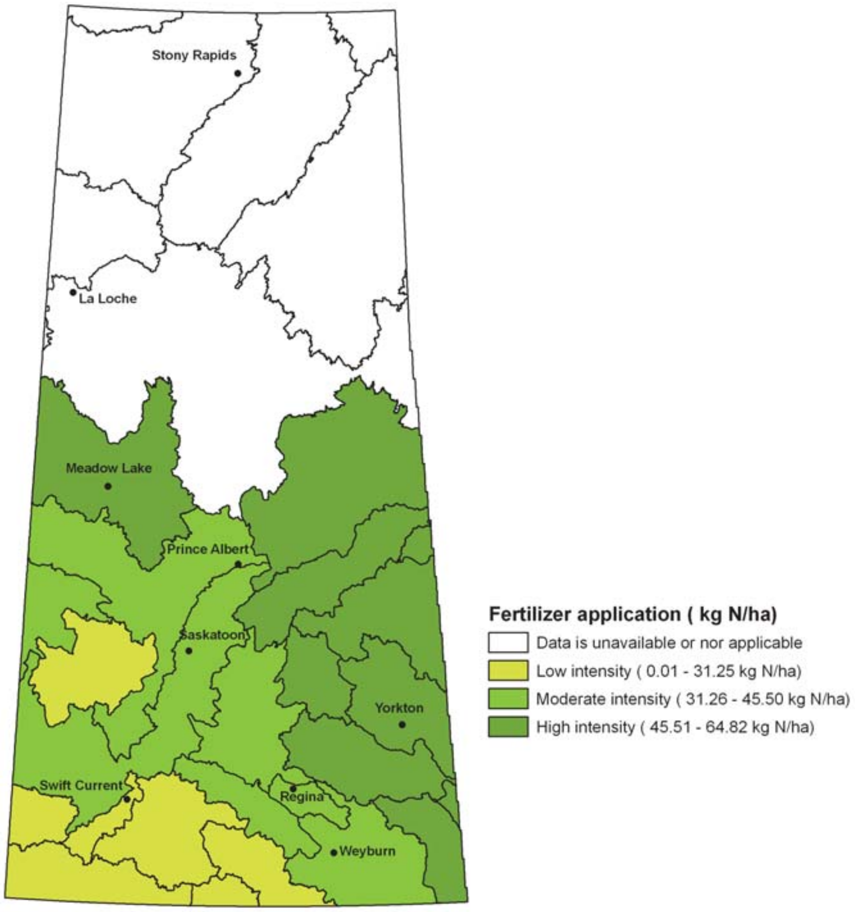

Figure 94. Nitrogen application rate from commercial fertilizer applied per watershed: 2006.
Note: Low, moderate, and high intensity categories were calculated based on the Jenks' optimization method and do not necessarily reflect intensity relative to actual recommended application rates.

For 2006, the rate of nitrogen application is classified as low intensity for seven watersheds, moderate intensity for seven watersheds , and high intensity for eight watersheds . The eight watersheds classified as high intensity are the Assiniboine River, Beaver River, Carrot River, Lake Winnipegosis, Lower Souris River, North Saskatchewan River, Quill Lakes, and Saskatchewan River Watersheds.

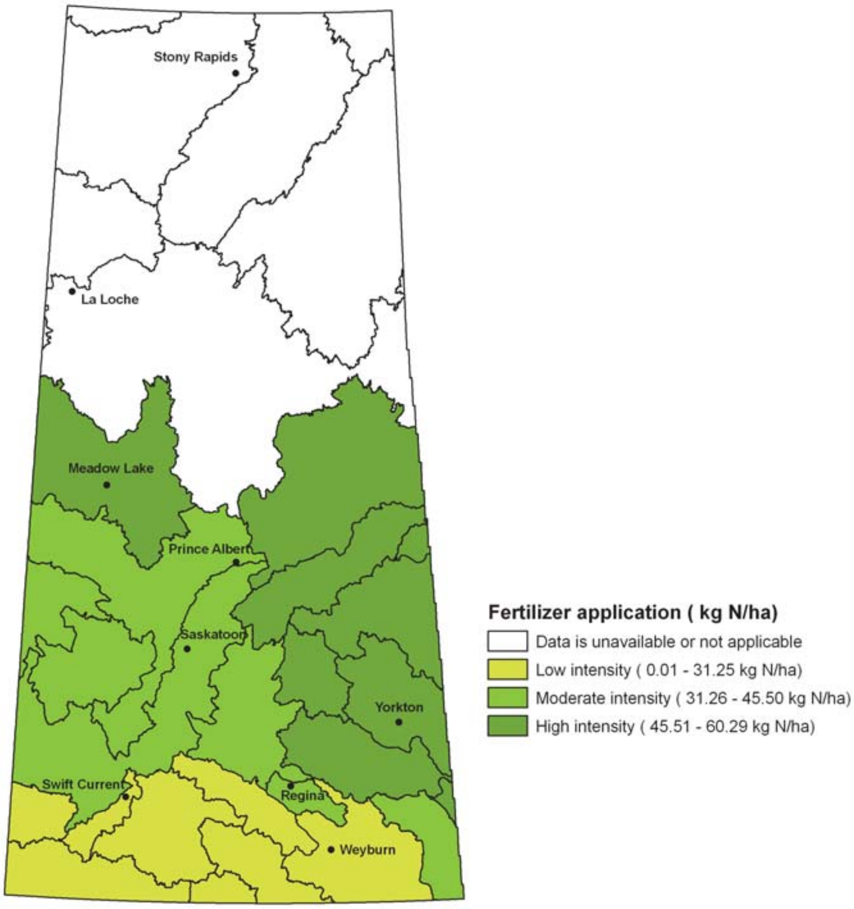

Figure 95. Nitrogen application rate from commercial fertilizer applied per watershed: 2001.
Note: Low, moderate, and high intensity categories were calculated based on the Jenks' optimization method and do not necessarily reflect intensity relative to actual recommended application rates.

For 2001, the nitrogen application rate is classified as low intensity for eight watersheds, moderate intensity for seven watersheds, and high intensity for seven watersheds.

The differences in the amount of nitrogen using commercial fertilizer by watershed in 2001 and 2006 include:

- There was a significant increase in the rate of nitrogen application per cropped area in seventeen of the twenty-two watersheds for which data were available. The five watersheds where the application of nitrogen did not increase between 2001 and 2006 are the Battle River, Beaver River, Eagle Creek, North Saskatchewan River, and Saskatchewan River Watersheds.

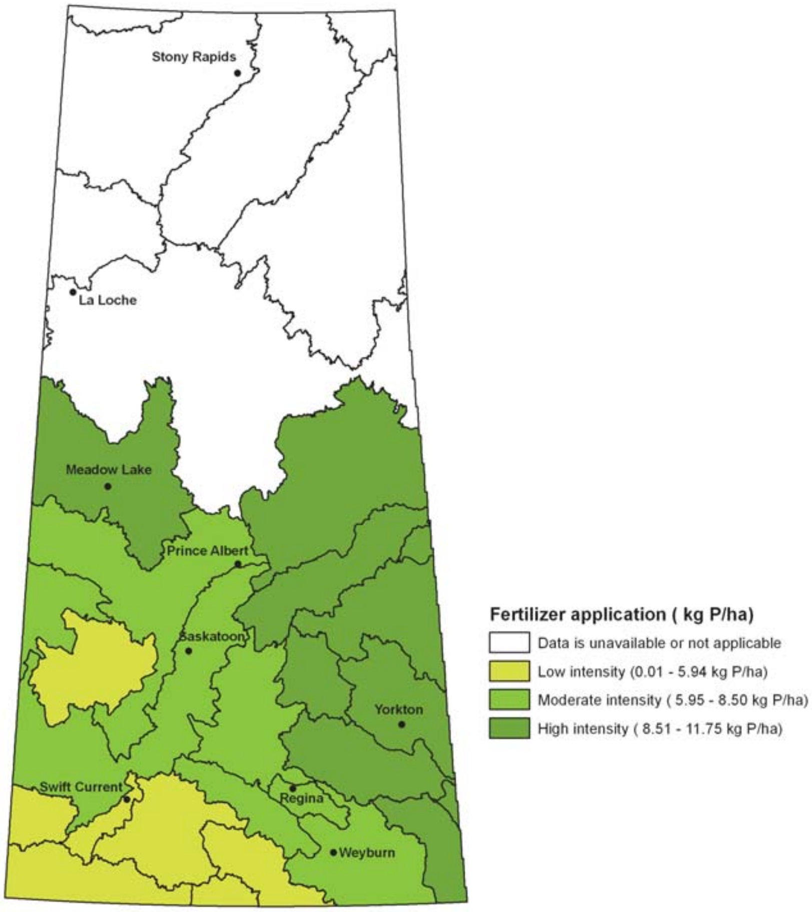

Figure 96. Phosphorus application rate from commercial fertilizer applied per watershed: 2006.
Note: Low, moderate, and high intensity categories were calculated based on the Jenks' optimization method and do not necessarily reflect intensity relative to actual recommended application rates.

For 2006, the phosphorus application rate is classified as low intensity for seven watersheds, moderate intensity for seven watersheds , and high intensity for eight watersheds.

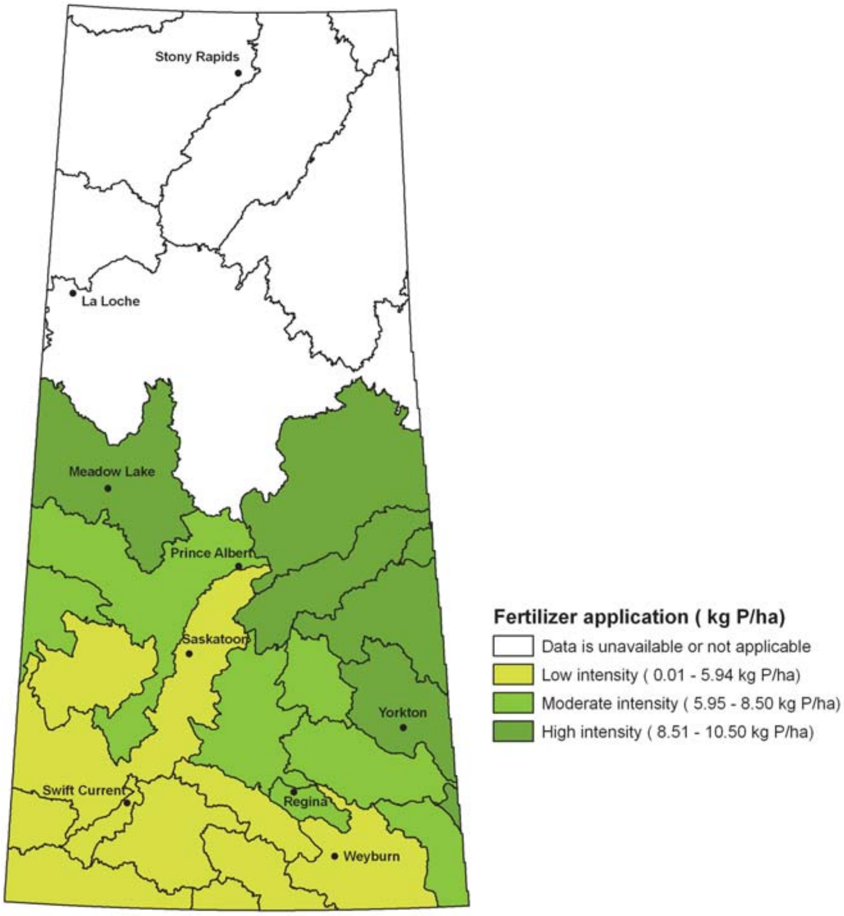

Figure 97. Phosphorus application rate from commercial fertilizer applied per watershed: 2001.
Note: Low, moderate, and high intensity categories were calculated based on the Jenks' optimization method and do not necessarily reflect intensity relative to actual recommended application rates.

For 2001, the rate of phosphorus application is classified as low intensity for 10 watersheds, moderate intensity for seven watersheds and high intensity for five watersheds .

The differences in the amount of phosphorus using commercial fertilizer by watershed between 2001 and 2006 include:

- There was a significant increase in the rate of phosphorus application per cropped area in eighteen of the twenty-two watersheds for which data were available. The four watersheds where the application of phosphorus did not increase between 2001 and 2006 are the Battle River, Beaver River, Eagle Creek and North Saskatchewan River Watersheds.

Watersheds with a small percentage of cultivated area and high fertilizer input costs have an increased potential risk of fertilizer contaminating local waterways and ground water. This applies to the Beaver River, Lake Winnipegosis, and Saskatchewan River Watersheds, which all have less than 25% of their land area in field crops.

Indicator		
Dollars Spent on Fertilizer (Watershed)	=	Fertilizer and lime purchases ($)
Proportion of Dollars Spent on Fertilizer	=	Dollars spent on fertilizer (watershed) / Dollars spent on fertilizer (province)
Tonnes of Fertilizer	=	Proportion of dollars spent on fertilizer by watershed x Total provincial retail sales of fertilizer (tonnes)
Rate of Fertilizer Applied (kg/ha)	=	Kilograms of fertilizer purchased / Annual field cropped area in watershed (ha)

Rating Scheme

Insufficient data from appropriate scientific studies existed to rate these fertilizer application rates, so the Jenks' optimization method was used to find the natural breaks in the data.

Nitrogen Application
Low intensity: The rate of application is less than 31.26 kg nitrogen/ha.
Moderate intensity: The rate of application is between 31.26 and 45.50 kg nitrogen/ha.
High intensity: The rate of application is greater than 45.50 kg nitrogen/ha.

Phosphorus Application
Low intensity: The rate of application is less than 5.95 kg phosphorus/ha.
Moderate intensity: The rate of application is between 5.95 and 8.50 kg phosphorus/ha.
High intensity: The rate of application is greater than 8.50 kg phosphorus/ha.

Methods: The method used to calculate the Fertilizer Inputs Indicator has been revised from the one used to calculate the Fertilizer Inputs Indicator in the 2007 *State of the Watershed Report*. In the 2007 *State of the Watershed Report*, only the dollars spent on fertilizer per watershed was calculated by dividing the fertilizer purchase value by the entire watershed area. In this report, the indicator is calculated using the tonnes of fertilizer-N and fertilizer-P that was purchased per watershed for only the annually field cropped area of the watershed.

Fertilizer nitrogen and phosphorus was calculated by multiplying Saskatchewan's retail fertilizer sales by the proportion of fertilizer used in each watershed. Nitrogen and phosphorus fertilizer use by watershed was calculated using the fertilizer and lime purchases from the farm business operating expenses tables in the 2001 and 2006 Census of Agriculture (Statistics Canada 2001 and 2006). Application rates were calculated by dividing the amount of fertilizer nitrogen and phosphorus used by the field cropped area within that watershed. The annual field cropped area was calculated by summing the field cropped area (ha) minus the alfalfa and alfalfa mixtures and other tame hay and fodder crops within a watershed using the field crops tables from the 2001 and 2006 Census of Agriculture (Statistics Canada 2001 and 2006).

Data Source: The data for the fertilizer and lime purchases are from the 2001 and 2006 Census of Agriculture, CGC (Census Geographic Component) databases (Statistics Canada 2001 and 2006). The retail sales statistics of the metric tonnes of nitrogen and phosphate from fertilizer sold to Saskatchewan in 2000 and 2001 is from the Canadian Fertilizer Institute. The annual field cropped areas are from the 2001 and 2006 Census of Agriculture, CGC (Census Geographic Component) databases (Statistics Canada 2001 and 2006). The annual field cropped area is equal to the field cropped area minus the alfalfa and alfalfa mixtures and other tame hay and fodder crops within a watershed using the field crops tables from the 2001 and 2006 Census of Agriculture (Statistics Canada 2001 and 2006).

Data Limitations: This indicator permits temporal and spatial trends to be analyzed. To further assess the potential impact of chemical application on watersheds an estimate of the mass of chemical loadings per watershed and the amount of fertilizer removed during cropping is needed. This would allow us to estimate the potential amount of excess fertilizer that has been added. Using this information a leaching potential and the runoff potential of nitrogen and phosphorus could be determined.

Data Discussion: To allow the comparison of the fertilizer inputs ($ amount) from the 2001 and 2006 Census of Agriculture, the 2001 data needed to be transformed into 2005 constant dollars, where 2005 was the reporting year for the fertilizer inputs ($ amount) in the 2006 Census of Agriculture. To convert the 2001 fertilizer inputs to 2005 dollars, the Farm Inputs Price Index (FIPI) was used. The FIPI measures the annual price movement of specified farm inputs at the farm gate.

Response to the issue

Fertilizers used in Canada are regulated under the *Fertilizers Act* and *Regulations*, administered by the Canadian Food Inspection Agency. Some of the activities that the Canadian Food Inspection Agency is involved with include: registration of fertilizers; review of fertilizer product safety, efficacy, and labelling; monitoring for active ingredients and contaminants in the market place; administering the Canadian Fertilizer Quality Assurance Program (CFQAP); and inspection and enforcement.

Within the Province of Saskatchewan, the Saskatchewan Ministry of Environment regulates *The Hazardous Substances and Waste Dangerous Goods Regulations* and *The Environmental Spill Control Regulations* under *The Environmental Management and Protection Act, 2002*. To receive and record province-wide reports of spills and environmental emergencies, the Saskatchewan Ministry of Environment established the Provincial Enforcement Centre Spill Report Line. Provincial Enforcement Centre staff can provide advice on reported spills and confirm if containment and cleanup measures are adequate.

The provincial and federal governments promote agricultural Beneficial Management Practices related to fertilizer application through the Canada-Saskatchewan Farm Stewardship Program. Agricultural Beneficial Management Practices related to fertilizer application include:

- product and waste management;
- improved cropping systems; and
- nutrient management planning.

To assist producers with fertilizer application, the Saskatchewan Ministry of Agriculture has developed several fact sheets, including:

- *Guidelines for Safe Rates of Fertilizer Placed with the Seed* (Saskatchewan Ministry of Agriculture 2009e);
- *Nitrogen Fertilization in Crop Production* (Saskatchewan Agriculture and Food 2005);
- *Phosphorus Fertilization in Crop Production* (Saskatchewan Agriculture and Food 2006);
- *Sulphur Fertilization in Crop Production* (Saskatchewan Agriculture and Food 2003b); and
- *Fertilizer Management for Seed Production of Perennial Forages in Saskatchewan* (Saskatchewan Ministry of Agriculture 2008).

In the *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series - Report #2* (Lefebvre et al. 2005), an indicator to assess the Risk of Water Contamination by Nitrogen (IROWC-N) was developed for all of Canada at a provincial scale (De Jong et al. 2005). IROWC-N looked at the risk of surface water bodies contaminated by nitrogen moving from agricultural areas treated with fertilizers and manure. It should be noted that IROWC-N has several limitations, as the calculation of this indicator involves many assumptions and approximations, and the results are estimates of the risk of water contamination by nitrogen. Despite these limitations, the IROWC-N does identify areas in Saskatchewan that are at risk for nitrogen losses to surface water bodies.

Pesticide Inputs Indicator

This indicator was developed to assess pesticide use by watershed.

Indicator	
Pesticide Inputs	**Status:** Currently, this indicator only assesses agricultural use of pesticides in Saskatchewan. However, it is recognized that pesticides are also used for industrial, commercial, government and domestic purposes. The method used to calculate the Pesticide Inputs Indicator has been revised from the one used to calculate the Pesticide Inputs Indicator in the 2007 *State of the Watershed Report* (see the **Methods** section on page 85 for details). **Trend:** Data from the 2001 and 2006 Census of Agriculture (CGC database) indicates that there was significant increase in the use of pesticides within Saskatchewan between 2001 and 2006.
Density of Pesticide Permits	**Status:** Between April 1, 2008 and March 31, 2009, the Saskatchewan Ministry of Agriculture issued 1,628 pesticide permits for the commercial application of pesticides. **Trend:** Currently data is not available to document trends over time.

The issue

Pesticides are used to control agricultural plant diseases and pests in order to increase crop quality and yield. Pesticides are synthetic compounds not found naturally in the environment. Some of these compounds can persist in the environment and have the potential to enter the aquatic ecosystems through leaching, surface runoff, and/or atmospheric deposition such as spray drift or wind erosion. Detectable concentrations of pesticides have been found in Saskatchewan lakes, wetlands and ground water (Donald et al. 1999, Donald and Syrgiannis 1995). Pesticides were found to persist in prairie farm dugouts, where the bottom sediments may store pesticides during certain times of the year while allowing pesticides to reach the water column during other times of the year (Cessna and Elliot 2004). Pesticides can have toxic effects on aquatic species by altering reproduction, behaviour, physiological processes, biochemical function, and survival of young and other sensitive life stages.

A report by the United States Environmental Protection Agency analyzed pesticide use by market sector and found that agriculture accounted for approximately 67% of pesticide use. Industry, commercial users and government accounted for approximately 13%, and home and garden use accounted for approximately 19% (Kiely et al. 2004). Data is presently unavailable to assess pesticide use in urban areas of Saskatchewan.

Pesticide Inputs Indicator in Saskatchewan

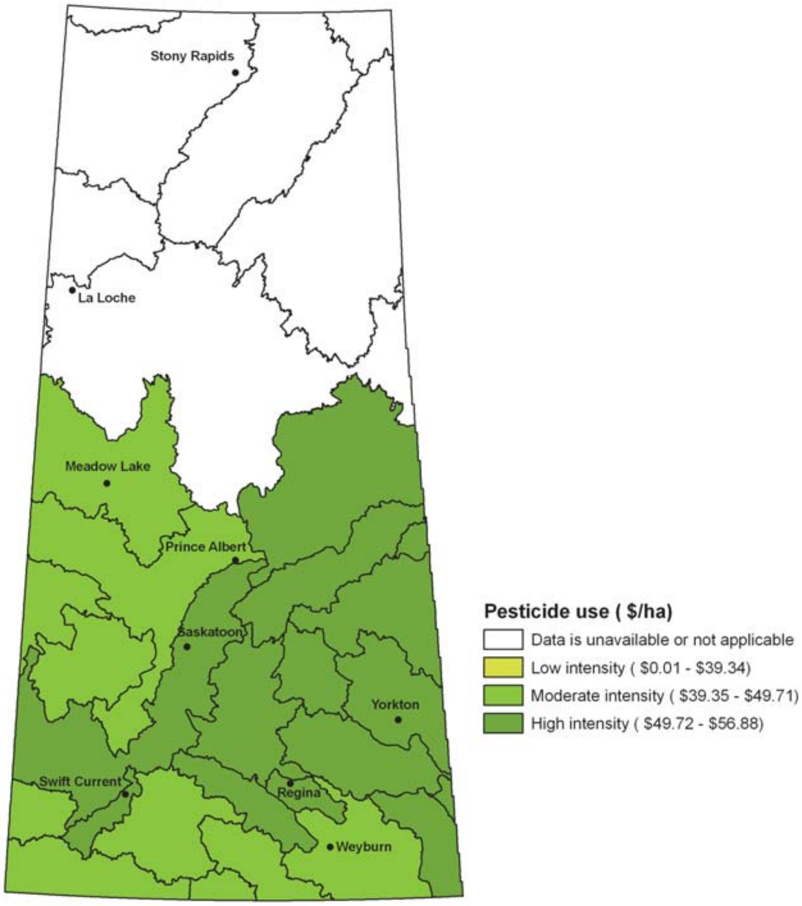

Figure 98. Pesticide use by watershed: 2006.

For 2006, ten watersheds are classified as moderate intensity, and twelve watersheds are classified as high intensity.

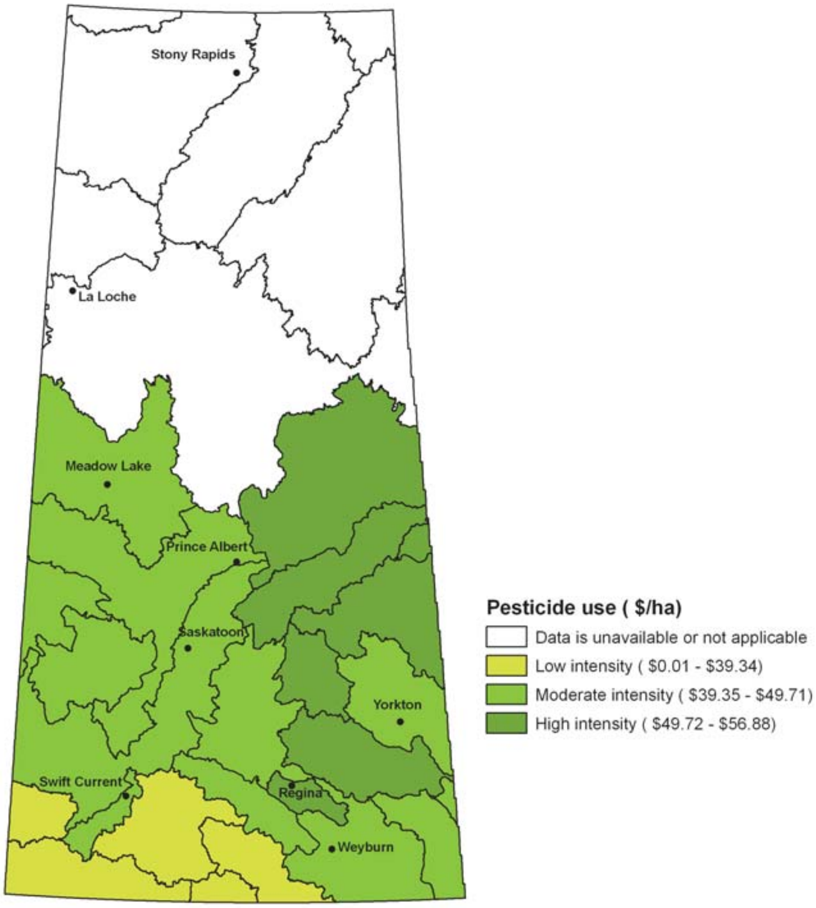

Figure 99. Pesticide use by watershed: 2001.

For 2001, pesticide use is classified as low intensity for five watersheds, moderate intensity for 11 watersheds, and high intensity for six watersheds.

Between 2001 and 2006, average pesticide use ($/ha) significantly increased for 19 of the 22 watersheds for which data are available. The three watersheds where pesticide use did not increase between 2001 and 2006 are the Eagle Creek, North Saskatchewan River, and Saskatchewan River Watersheds.

In an attempt to further assess pesticide use in Saskatchewan, an additional component was added to the pesticide indicator which looks at the density of commercial pesticide permits in Saskatchewan by watershed. To commercially apply pesticides in Saskatchewan, applicators must obtain a permit from the Saskatchewan Ministry of Agriculture. The Ministry of Agriculture issues permits for the commercial application of pesticides for agricultural applications, aerial applications, aquatic applications, fumigation, greenhouse use, industrial use, landscape use, to control mosquitoes and biting flies, for seed treatment, and for structural and structural-restricted purposes (which is for rat control only).

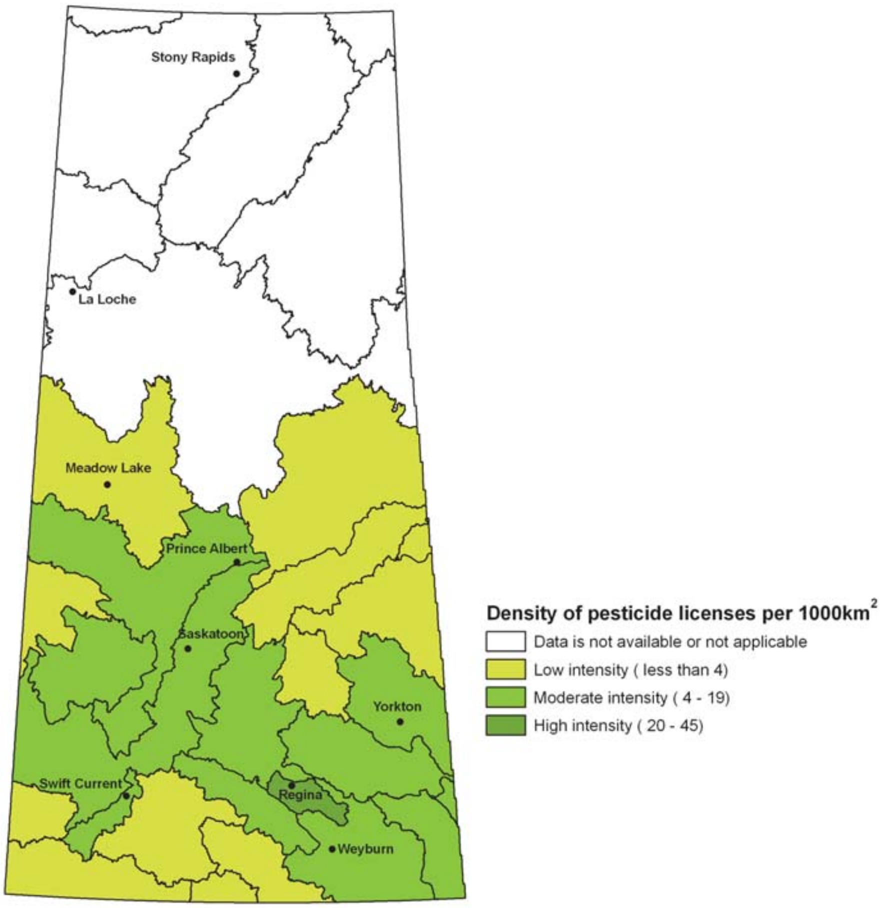

Figure 100. Density of pesticide licenses: 2008.

Between April 1, 2008 and March 31, 2009, the Saskatchewan Ministry of Agriculture issued 1,628 pesticide application permits. Eleven watersheds have a low density of pesticide permits issued, ten watersheds have a moderate density of pesticide permits issued, and the Wascana Creek Watershed has a high density of pesticide permits issued. Of the 1,628 pesticide permits, agriculture accounted for 26%, followed by landscape (20%), industrial use (19%), structural (10%), mosquitoes and biting flies (7%), structural-restricted purposes (6%), aerial applications (4%), and seed treatment (3%). Fumigation, greenhouse use and aquatic applications each accounted for 2%.

Indicator		
Pesticide Input Intensity	=	$\frac{\text{Pesticide input cost (\$)}}{\text{Annual field cropped area in watershed (ha)}}$
Density of Pesticide Licenses	=	$\frac{\text{Number of pesticide licenses issued}}{\text{Watershed area (ha)}}$

Rating Scheme
Insufficient data from appropriate scientific studies existed to rate this indicator, so, the Jenks' optimization method was used to find the natural breaks in the data.

Pesticide Input Intensity
Low intensity: Pesticide use is less than $39.35/hectare.
Moderate intensity: Pesticide use is between $39.35 and $49.71/hectare.
High intensity: Pesticide use is greater than $49.71/hectare.

Pesticide License Density
Low intensity: Density of pesticide licenses is less than 4 per 1,000 km^2.
Moderate intensity: Density of pesticide licenses is between 4 and 19 per 1,000 km^2.
High intensity: Density of pesticide licenses is greater than 19 per 1,000 km^2.

Methods: The method used to calculate the Pesticide Inputs Indicator has been revised from the one used to calculate the Pesticide Inputs Indicator in the 2007 *State of the Watershed Report*. In the 2007 *State of the Watershed Report* the dollars spent on pesticides within the watershed was divided by the entire watershed area. In this report the purchases of pesticides per watershed was divided by the field cropped area (ha) minus the alfalfa and alfalfa mixtures and other tame hay and fodder crops (ha). The field cropped area (ha) within a watershed was calculated using the field crops tables from the 2001 and 2006 Census of Agriculture (Statistics Canada 2001 and 2006).

Data Source: Pesticide use data for this indicator were obtained from the 2001 Census of Agriculture, CGC (Census Geographic Component) database and the 2006 Census of Agriculture, CGC (Census Geographic Component) database (Statistics Canada 2001 and 2006). The annual field cropped areas are from the 2001 and 2006 Census of Agriculture, CGC (Census Geographic Component) databases (Statistics Canada 2001 and 2006). The annual field cropped area is equal to the field cropped area (ha) minus the alfalfa and alfalfa mixtures and other tame hay and fodder crops (ha) within a watershed using the field crops tables from the 2001 and 2006 Census of Agriculture (Statistics Canada 2001 and 2006). The number of pesticide licenses issued for the period Jan 1, 2008 to March 12, 2009 was provided by the Saskatchewan Ministry of Agriculture.

Data Discussion: To allow the comparison of the pesticide inputs ($ amount) from the 2001 and 2006 Census of Agriculture, the 2001 data needed to be transformed into 2005 constant dollars, where 2005 was the reporting year for the pesticide inputs ($ amount) in the 2006 Census of Agriculture. To convert the 2001 pesticide inputs to 2005 dollars, the Farm Inputs Price Index (FIPI) was used. The FIPI measures the annual price movement of specified farm inputs at the farm gate.

The Pesticide Inputs Indicator allows for temporal and spatial trends to be analyzed. However, it does not directly measure the potential impact pesticides have on the health of watersheds. To further assess the potential impact of pesticide application on watersheds, an estimate of the mass of chemical loadings per watershed is needed. Using the current data it is not possible to calculate chemical loading to waterways. However, as the new *Pest Control Products Sales Information Reporting Regulations* requires registrants to annually report product sales information to Health Canada, there is a possibility that this information will be available for the next *State of the Watershed Report*.

Response to the issue

All pesticides imported into, sold, or used in Canada are regulated under the *Pest Control Products Act* and *Regulations*, administered by the Pest Management Regulatory Agency (PMRA) of Health Canada. Some of the activities the PMRA is involved with include registering pest control products, re-evaluating registered products, and setting maximum residue limits under the *Food and Drugs Act* (Health Canada 2003). In November 2006, the *Pest Control Products Sales Information Reporting Regulations were published under the Pest Control Products Act.* These Regulations require registrants to annually report product sales information to Health Canada. This information will be used by Health Canada to assist in developing risk indicators to better assess health and environmental risks associated with pesticide use.

Within the province of Saskatchewan, the Saskatchewan Ministry of Agriculture regulates the sale, use, storage, transportation and disposal of registered pesticides under *The Pest Control Products (Saskatchewan) Act* and *Regulations, 1995*. The *Hazardous Substances and Waste Dangerous Goods Regulations* and *The Environmental Spill Control Regulations*, under *The Environmental Management and Protection Act, 2002,* are administered by the Saskatchewan Ministry of Environment.

The Saskatchewan Ministry of Environment established the Provincial Enforcement Centre Spill Report Line to receive and record province-wide reports of spills and environmental emergencies. Provincial Enforcement Centre staff can provide advice on reported spills and confirm if containment and cleanup measures are adequate.

The Government of Saskatchewan promotes licensing and education through such initiatives as:

- The Pesticide Applicator License, which is mandatory for all individuals and employees who conduct custom pesticide application. Prior to obtaining a license, applicants must complete and pass the pesticide training course offered through the Saskatchewan Institute of Applied Science and Technology (SIAST).
- The Government of Saskatchewan does not require individuals who purchase and apply pesticides for their personal use to obtain a pesticide application certificate. However, individuals applying pesticides on their own property can obtain a voluntary Private Pesticide Applicator Certificate (Saskatchewan Ministry of Agriculture, Unpublished).
- The Saskatchewan Ministry of Agriculture releases the *Guide to Crop Protection* in May of each year. This annually-updated document provides information on the use of pesticides for the control of undesirable weeds, plant diseases and insects. It contains corrections and new uses that have been registered since the previous printing.
- Pesticide labels provide users with information that, if followed, reduces the risk of pesticide contamination to surface and ground water. All registered pesticides must have a label attached to the pesticide container. The label includes the name of the pesticide, its toxicity and hazard rating, the concentration of the active ingredient, directions for use including the application rate, and information on first aid treatment.

In addition to legislation and education, the federal and provincial governments both promote Beneficial Management Practices in Saskatchewan through the Canada-Saskatchewan Farm Stewardship Program. Beneficial Management Practices related to pesticide application include:

- product and waste management;
- improved pest management; and
- integrated pest management planning.

The Government of Saskatchewan's Noxious Weed Management Program encourages integrated weed control through a combined approach of physical, chemical, biological and ecological methods. Research is also being done on integrated pest management in the province, including:

- Staff at Agriculture and Agri-Food Canada's Saskatoon Research Centre are conducting research on weed biocontrol. The goal of the program is to reduce the producer's dependency on chemical herbicides through the development of microbial weed biocontrol agents for use in agricultural systems.
- Staff at Agriculture and Agri-Food Canada's Saskatoon Research Centre are conducting research on ecological pest management. The research is focused on four components:
  - biological control of weeds;
  - biological control of insect pests;
  - resistance to insects in canola; and
  - integrated management tactics.

Manure Production Indicator

The manure production indicator was developed to identify the amount of manure produced in Saskatchewan at a watershed level, and the annual quantity of nitrogen and phosphorus found in livestock manure.

Indicator	
Total Livestock Manure Production	**Status:** The method used to calculate the Manure Production Indicator has been revised from the one used to calculate the Manure Application Indicator in the 2007 *State of the Watershed Report* (see the **Methods** section on page 95 for details). **Trend:** Total livestock manure production increased in 2006 compared to 2001.
Nitrogen Production in Livestock Manure	**Trend:** Nitrogen production in livestock manure increased in 2006 compared to 2001.
Phosphorus Production in Livestock Manure	**Trend:** Phosphorus production in livestock manure increased in 2006, compared to 2001.

The issue

Several watershed health risks are associated with livestock manure production and handling. Manure is an excellent plant fertilizer containing nitrogen, phosphorus, potassium and other nutrients that plants need. Manure is also a potential source of pathogens and pharmaceuticals within watersheds. While a substantial number of studies have examined nutrient and pathogen risks, there is less known about potential effects of pharmaceuticals. In response to this knowledge gap, a recent study in Saskatchewan examined the movement of antimicrobial compounds into surface and ground water (Kuchta and Cessna 2009). The study found that antimicrobials from manure can contaminate surface and ground water. However, it is not yet known at what concentrations these will affect local ecosystems, including the increased resistance of microbial communities in the environment.

Manure Production Indicator in Saskatchewan

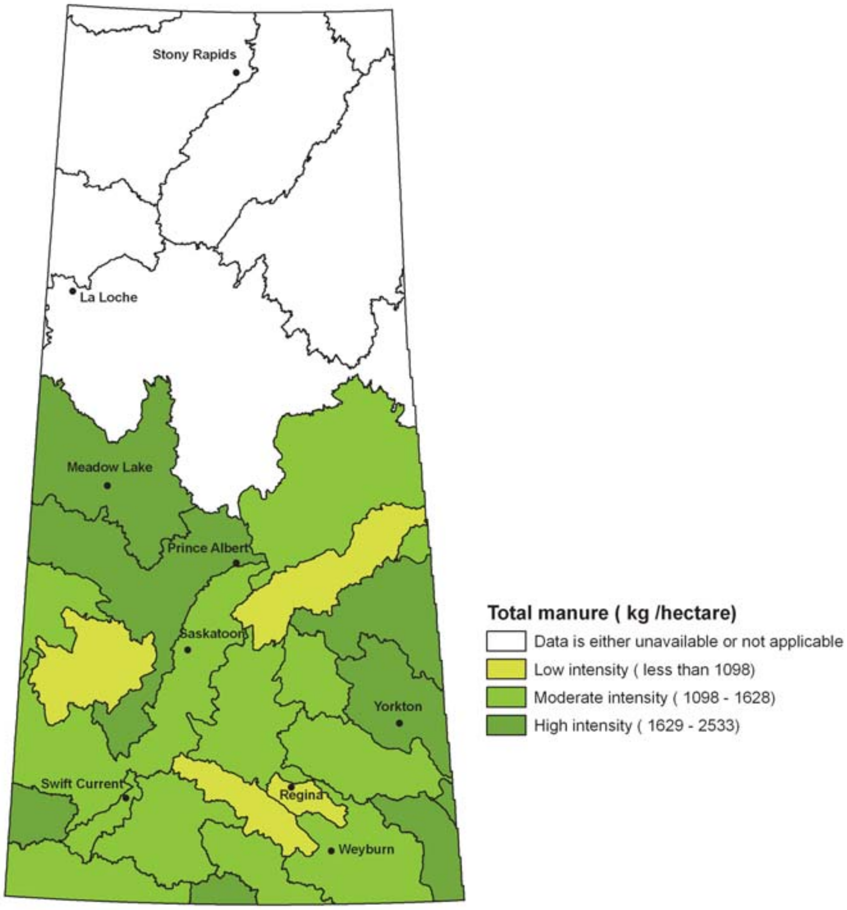

Figure 101. Estimated total livestock manure production by watershed: 2006.

In 2006, livestock produced an estimated 34 billion kilograms of manure. Of this total amount of livestock manure, 56% was produced by beef cows, followed by calves (16%), heifers (9%), steers (6%), pigs (4%), bulls (3%), dairy cows (2%), horses (2%) and poultry (1%). All other livestock produced less than 1% of the total amount of manure. Figure 101 shows the distribution of livestock manure production by watershed in 2006. The seven watersheds categorized as high intensity are the Assiniboine River, Beaver River, Cypress Hills North Slope, Lake Winnipegosis, Lower Souris River, North Saskatchewan River, and Poplar River Watersheds.

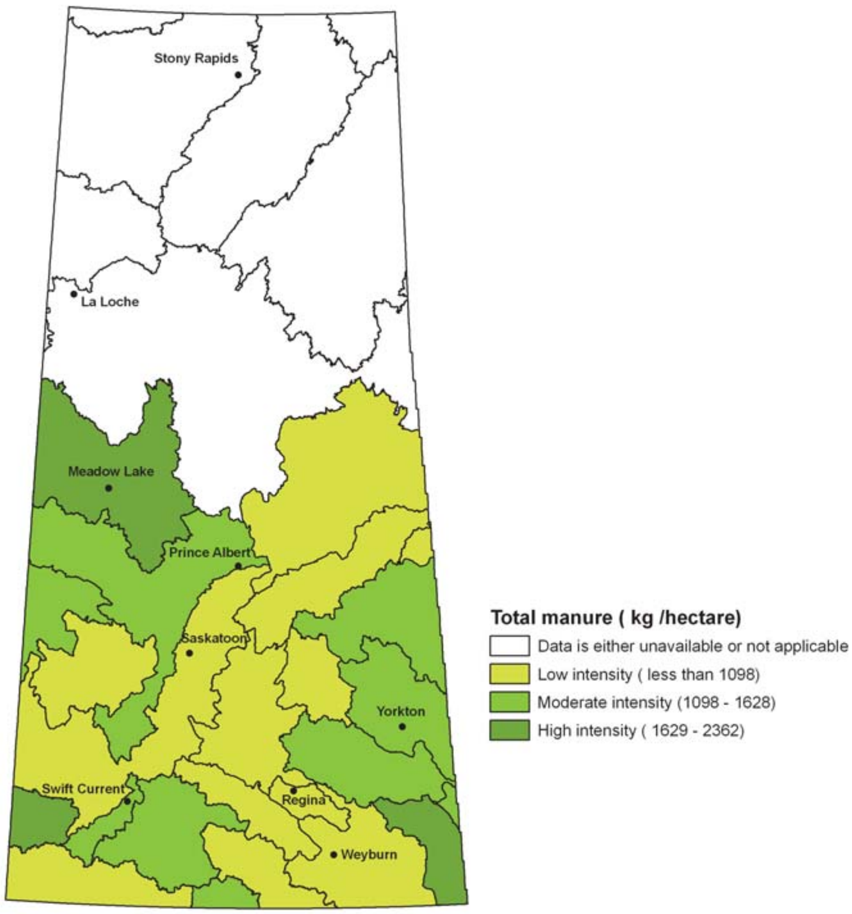

Figure 102. Estimated total livestock manure production by watershed: 2001.

In 2001, livestock produced an estimated 29 billion kilograms of manure. Of this total amount of livestock manure, 55% was produced by beef cows, followed by calves (17%), heifers (9%), steers (5%), pigs (4%), bulls (3%), dairy cows (2%) and poultry (1%). All other livestock produced less than 1% of the total amount of manure. Figure 102 shows the distribution of livestock manure production by watershed in 2001. The three watersheds categorized as high intensity are the Beaver River, Cypress Hills North Slope, and Lower Souris River Watersheds.

Total manure production increased by 17% in 2006 compared to 2001. More watersheds were classified as high or moderate intensity in 2006 than in 2001.

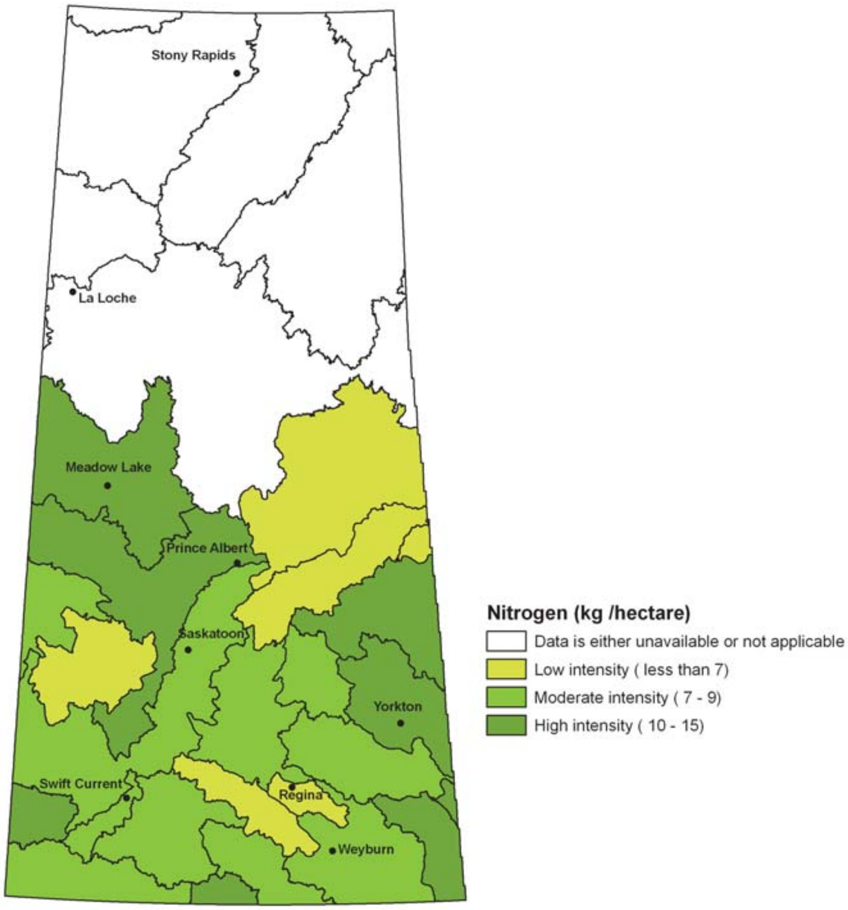

Figure 103. Estimated nitrogen production in livestock manure by watershed: 2006.

In 2006, livestock produced an estimated 204 million kilograms of nitrogen in their manure. Figure 103 shows the estimated total amount of nitrogen from livestock manure by watershed in 2006. The seven watersheds categorized as high intensity are the Assiniboine River, Beaver River, Cypress Hills North Slope, Lake Winnipegosis, Lower Souris River, North Saskatchewan River, and Poplar River Watersheds.

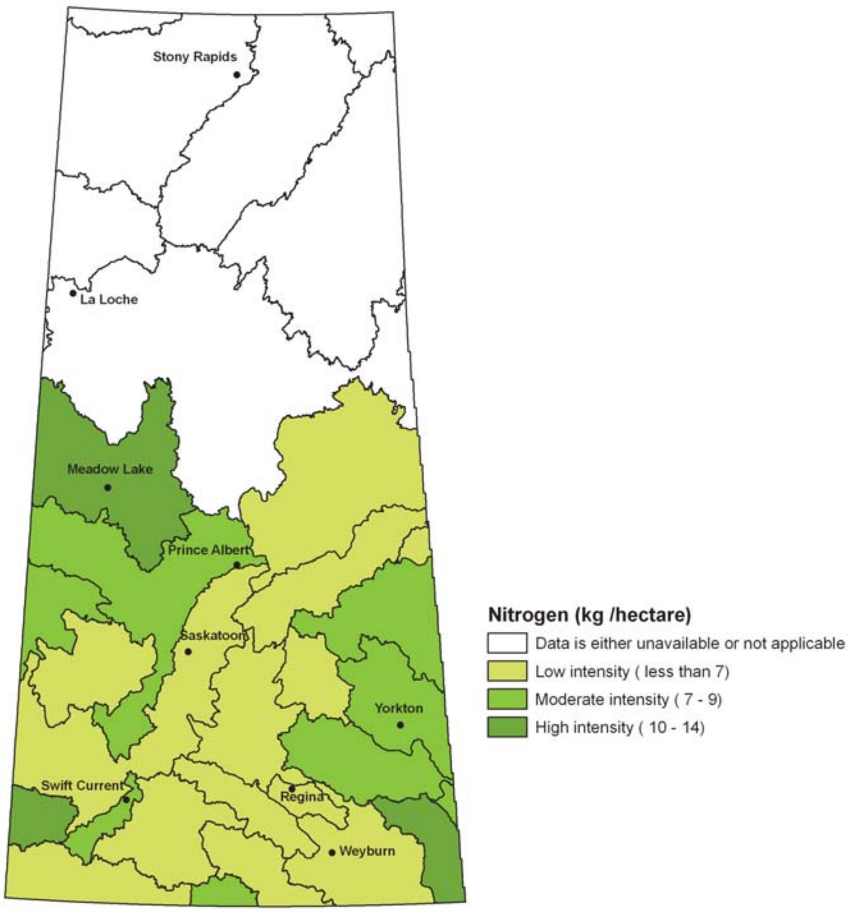

Figure 104. Estimated nitrogen production in livestock manure by watershed: 2001.

In 2001, livestock produced an estimated 175 million kilograms of nitrogen in their manure. Figure 104 shows the estimated total amount of nitrogen from livestock manure by watershed in 2001. The three watersheds categorized as high intensity are the Beaver River, Cypress Hills North Slope, and Lower Souris River Watersheds.

In 2006, nitrogen production in livestock manure increased by 17% compared to 2001. More watersheds were classified as high or moderate intensity in 2006 compared to 2001.

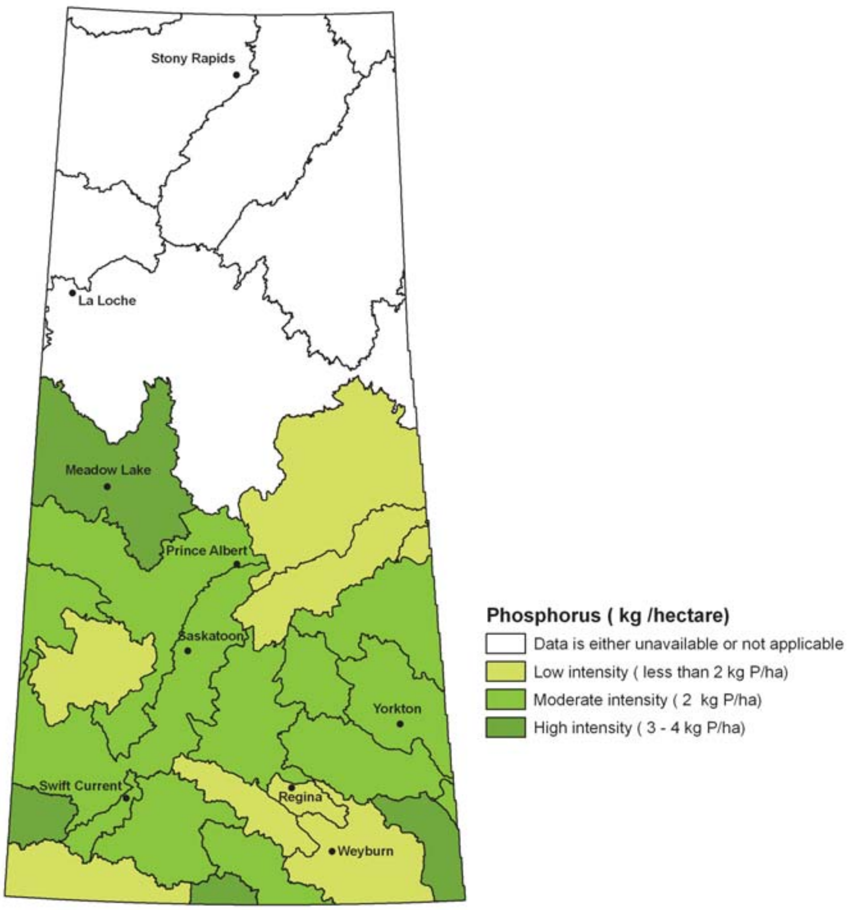

Figure 105. Estimated phosphorus production in livestock manure by watershed: 2006.

In 2006, livestock produced approximately 56 million kilograms of phosphorus in their manure. Figure 105 shows the estimated total amount of phosphorous from livestock manure by watershed in 2006. The four watersheds categorized as high intensity are the Beaver River, Cypress Hills North Slope, Lower Souris River, and Poplar River Watersheds.

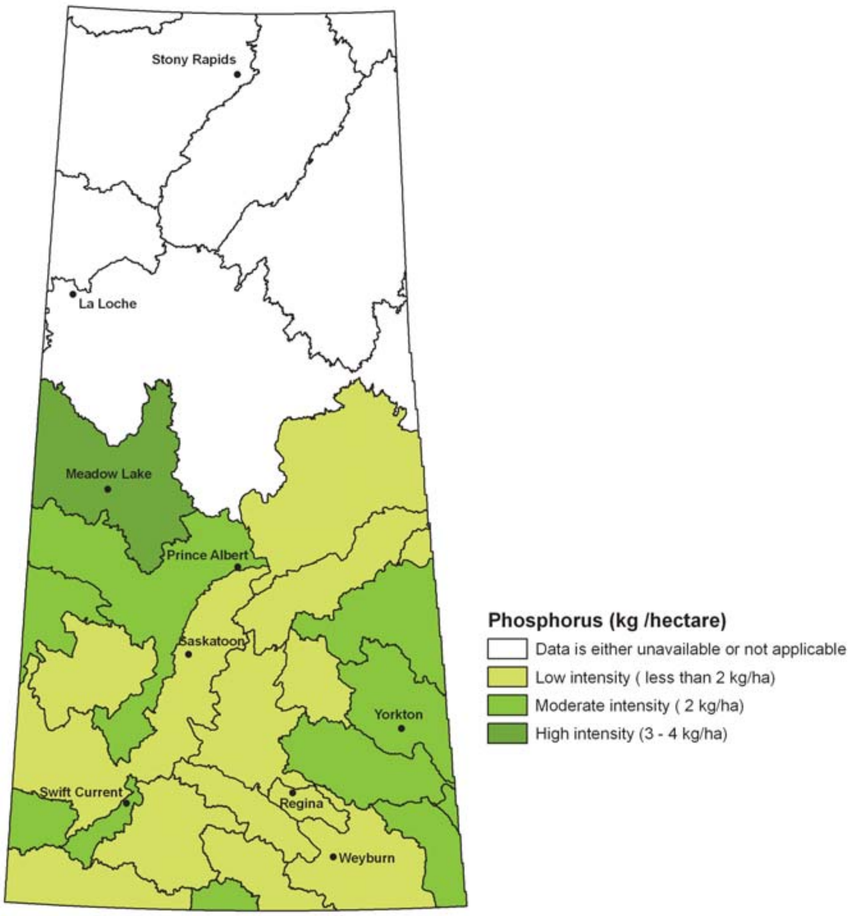

Figure 106. Estimated phosphorus production in livestock manure by watershed: 2001.

In 2001, livestock produced an estimated 48 million kilograms of phosphorus in their manure. Figure 106 shows the estimated total amount of phosphorus from livestock manure by watershed in 2001. The only watershed categorized as high intensity is the Beaver River Watershed.

In 2006, phosphorus production in livestock manure increased by 17% compared to 2001. More watersheds were classified as high or moderate intensity in 2006 compared to 2001.

Indicator		
Total Manure (kg)	=	Livestock population x manure coefficient (kg)
Nitrogen in Livestock Manure (kg)	=	Livestock population x nitrogen manure coefficient (kg)
Phosphorus in Livestock Manure (kg)	=	Livestock population x phosphorus manure coefficient (kg)
Total Manure Production by Watershed (kg/ha)	=	$\frac{\text{Total manure (kg)}}{\text{Cropped land + summerfallow land + tame or seeded pasture + natural land for pasture (ha)}}$
Nitrogen Production in Manure by Watershed (kg/ha)	=	$\frac{\text{Nitrogen in livestock manure (kg)}}{\text{Cropped land + summerfallow land + tame or seeded pasture + natural land for pasture (ha)}}$
Phosphorus Production in Manure by Watershed (kg/ha)	=	$\frac{\text{Phosphorus in livestock manure (kg)}}{\text{Cropped land + summerfallow land + tame or seeded pasture + natural land for pasture (ha)}}$

Rating Scheme

Insufficient data from appropriate scientific studies existed to rate this indicator, so the Jenks' optimization method was used to find the natural breaks in the data. A Statistics Canada publication was released in 2001 that profiled manure production in Canada (Hofmann and Kemp 2001). The study had similar category breaks to the ones used here.

Total Livestock Manure Production
Low intensity: Manure production is less than 1,098 kg/hectare.
Moderate intensity: Manure production is between 1,098 and 1,628 kg/hectare.
High intensity: Manure production is more than 1,628 kg/hectare.

Nitrogen Production in Livestock Manure
Low intensity: Nitrogen production is less than 7 kg/hectare.
Moderate intensity: Nitrogen production is between 7 and 9 kg/hectare.
High intensity: Nitrogen production is equal to or more than 10 kg/hectare.

Phosphorus Production in Livestock Manure
Low intensity: Phosphorus production is less than 2 kg/hectare.
Moderate intensity: Phosphorus production is equal to 2 kg/hectare.
High intensity: Phosphorus production is more than 2 kg/hectare.

Methods: The method used to calculate the Manure Production Indicator has been revised from the one used to calculate the Manure Application Indicator in the 2007 *State of the Watershed Report*. In the 2007 *State of the Watershed Report* the reported area of manure application within the watershed was divided by the entire watershed area. In this report the production of total manure, nitrogen in livestock manure and phosphorus in livestock manure by watershed are calculated and then divided by the field cropped area, summerfallow land, tame or seeded pasture and natural land for pasture. The field cropped area, summerfallow land, tame or seeded pasture and natural land for pasture within a watershed was calculated from the 2001 and 2006 Census of Agriculture (Statistics Canada 2001 and 2006).

Data Source: Livestock populations were obtained from the 2001 and 2006 Census of Agriculture, CGC (Census Geographic Component) databases (Statistics Canada 2001 and 2006). Manure coefficients were obtained from *Interpolated Census of Agriculture to Soil Landscapes, Ecological Frameworks, and Drainage Areas of Canada: Documentation and User Guide* (Agriculture and Agri-Food Canada 2007).

Data Quality/Caveats: The values calculated for this indicator are estimates. Some of the assumptions made to calculate this indicator include:

- livestock of a certain type produce the same amounts of manure, and that manure has the same nitrogen and phosphorus content.
- Canadian livestock produce similar amounts of manure, and nitrogen and phosphorus content as the same type of livestock from the United States. The coefficients outlined in the *Interpolated Census of Agriculture to Soil Landscapes, Ecological Frameworks, and Drainage Areas of Canada: Documentation and User Guide* (Agriculture and Agri-Food Canada 2007) are based on values calculated for livestock from the United States.

livestock populations from the 2001 and 2006 Census of Agriculture data were used to extrapolate the manure production for the entire year.

Data Discussion: To further assess the potential impact of manure application on watersheds, an estimate of the potential risk of nitrogen and phosphorus loading to surface water bodies should also be considered.

Response to the issue

Nutrient management planning when applying manure is an important agricultural Beneficial Management Practice that can be used by livestock producers to reduce nutrient loading from manure to surface and ground water. There are several ways that producers can reduce the potential of nutrient contamination to water sources. These include: 1) applying manure at an application rate that will meet the nutrient requirements of the crop; 2) reducing excess phosphorus in the manure; and 3) employing liquid manure injection practices that minimize nutrient runoff concerns.

A number of Beneficial Management Practices are promoted through the Canada-Saskatchewan Farm Stewardship Program which have the potential to reduce the environmental risk of manure application in Saskatchewan, including:

- improved manure storage and handling;
- manure treatment; and
- manure land application.

The Saskatchewan Ministry of Agriculture has a number of documents related to applying and handling livestock manure on their website, including:

- Manure Application Rates;
- Manure and the Protection of Water, Soil and Air;
- Manure Sampling and Analysis;
- Soil Sampling and Analysis;
- Understanding Manure;
- Understanding the Soil and Manure Test Reports;
- Economic Value of Liquid Hog Manure;
- Fertilizing Forages with Manure;
- Composting Solid Manure; and
- Manure Spills.

These documents can be found online at: http://www.agriculture.gov.sk.ca/Default.aspx?DN=84596c25-26e1-40fa-aca5-b9f9b15548fc.
Or
http://www.agriculture.gov.sk.ca/Default.aspx?DN=4f62b99a-ae55-407a-bc0b-9f6bfa43b94c.
Or http://www.agriculture.gov.sk.ca/adx/aspx/adxGetMedia.aspx?DocID=1913,336,185,81,1,Documents&MediaID=6769&Filename=forages_manure.pdf
Or
http://www.agriculture.gov.sk.ca/Manure_Handling_Guide

Wetland Loss Indicator

This indicator measures the percentage of wetland area loss in Saskatchewan.

Indicator	
Wetland Loss	**Status:** Inventory and research continued to be conducted on wetlands in Saskatchewan. The information collected contributes to a deeper understanding of the benefits of wetlands and the impact of wetland loss on ecosystems in Saskatchewan. The data source used to calculate the Wetland Loss Indicator has been revised from the one used to calculate the Wetland Loss Indicator in the 2007 *State of the Watershed Report* (see the **Data Source** section on page 101 for details). **Trend:** Fine-scale data are currently unavailable to determine the trend in wetland loss across the province.

The issue

Wetlands play a fundamental role in ecosystem structure and function. The abundance, distribution and type of wetlands varies regionally, reflecting differences in glacial history, soils, topography, and climate. Saskatchewan is blessed with a wetland resource of continental importance; about 40% of the wetlands within the Prairie Pothole Region of North America are located here (United States Fish and Wildlife Services 2008a, 2008b, 2008c, 2008d, and 2008e). Wetlands provide many environmental benefits including the provision of wildlife habitat, water storage and flood control, sources for ground water recharge, nutrient and sediment sinks, contaminant removal, and pathogen reduction. The magnitude of these benefits varies among regions. There is little known about the cumulative landscape effects of wetlands in Saskatchewan, notably a lack of understanding of how many wetlands are needed to preserve basic ecosystem function.

Human impacts on wetlands occur for several reasons, including urban, rural and industrial development and agricultural practices. Some of the ways humans impact wetlands include infilling, grading, draining, nutrient/sediment deposition, and vegetation disturbance/removal. Drainage wetlands on agricultural land is practiced to allow for earlier seeding dates, to increase seeded acreage, and to increase efficiency and decrease producer costs by eliminating the need to work around wetlands. This latter point is especially important as farming equipment increases in size.

The area of historic wetlands that have been drained is unknown at regional scales. The Wetland Loss Indicator is therefore an estimate based on data collected since 1985 from sub-samples of portions of Saskatchewan. It provides a basis for assessing the potential risk to prairie ecosystem health associated with wetland drainage.

Wetland Loss Indicator in Saskatchewan

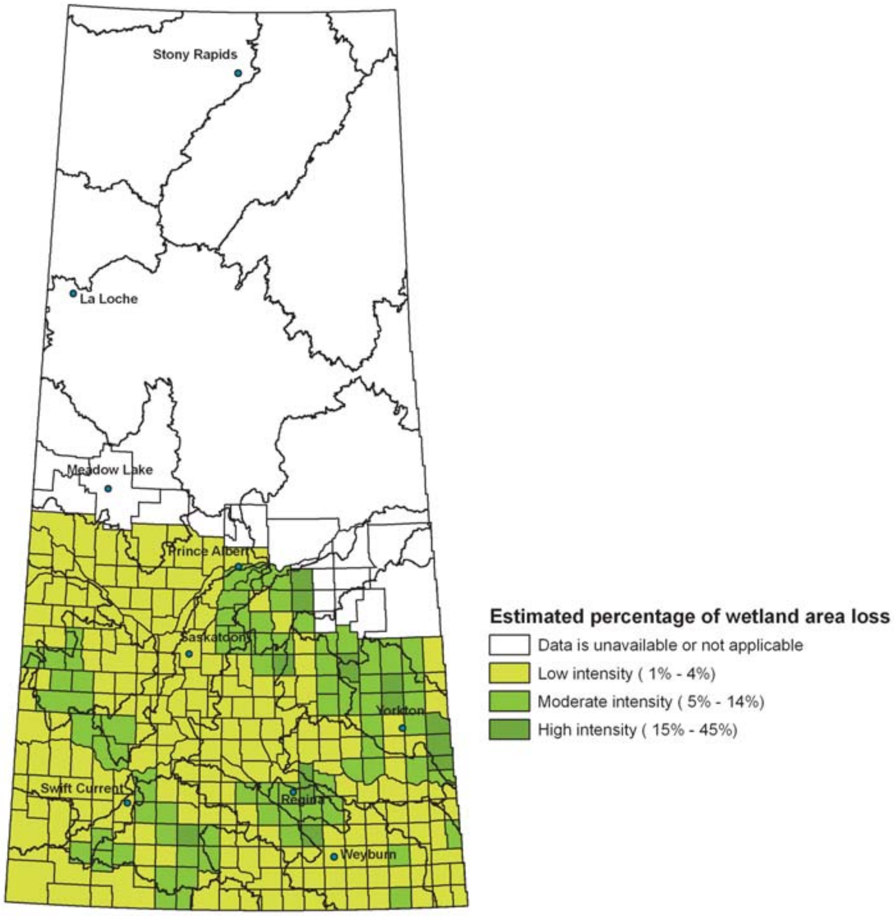

Figure 107. Estimated gross percent of wetland area loss by watershed: 1985-2001.
Note: the low, moderate and high intensity categories are relative wetland loss values within Saskatchewan.

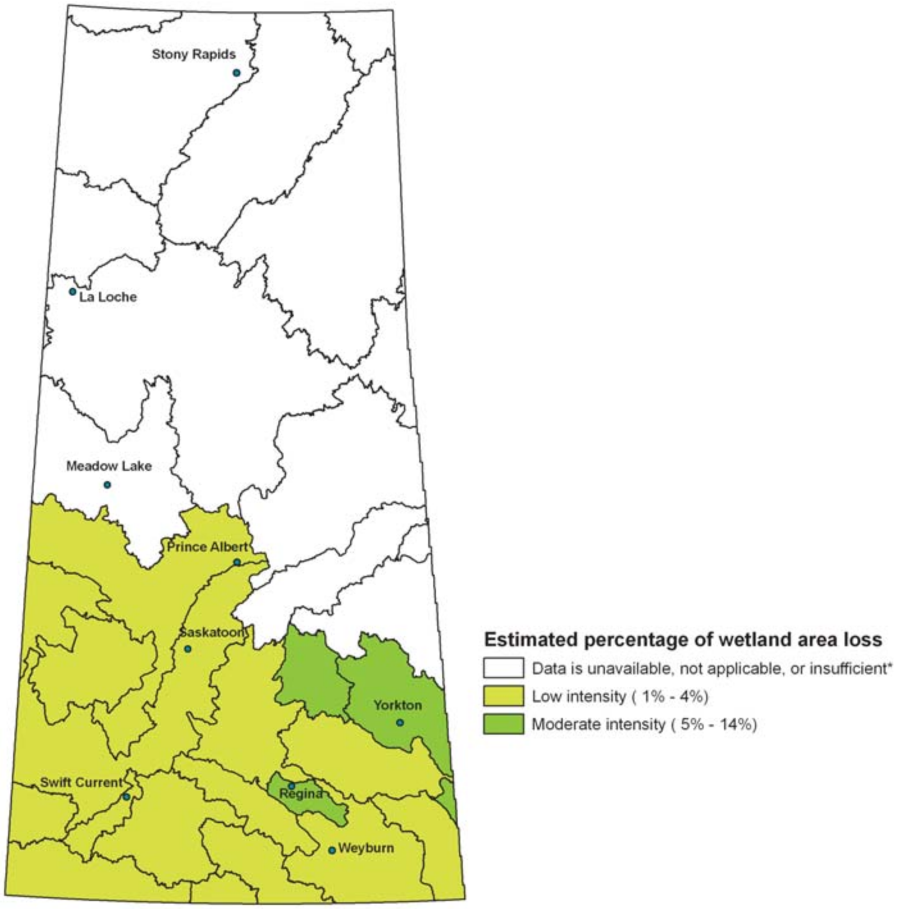

Figure 108. Interpolated estimate of cumulative wetland area loss by watershed: 1985-2001.
Note: the low, moderate and high intensity categories are relative wetland loss values within Saskatchewan.
*Less than 50% of the watershed had wetland loss values.

The estimated percentage of wetland area loss due to drainage is classified as low intensity for 15 watersheds and moderate intensity for three watersheds. The cumulative wetland drainage is estimated to be greatest in the Assiniboine River, Quill Lakes and Wascana Creek Watersheds. Other watersheds where considerable drainage is thought to have occurred include the Upper Qu'Appelle River and Upper Souris River Watersheds. The effects of the long-term, cumulative wetland loss due to drainage within Saskatchewan are currently unknown, and more study is required to address this question.

The largest and most comprehensive wetland inventory in Saskatchewan to date was conducted in the Lower Souris River Watershed. In 2007, the Lower Souris River Watershed Committee Inc., Agriculture and Agri-Food Canada's Agri-Environment Services Branch (AAFC-AESB), Ducks Unlimited Canada, and the Saskatchewan Watershed Authority entered into an agreement to develop a comprehensive land cover inventory for the Lower Souris River Watershed. The purpose of the inventory was to quantify the abundance and distribution of aquatic and terrestrial habitats within the watershed (Boychuk 2009). The inventory assessed the entire Lower Souris River Watershed and found the land cover within the watershed was comprised of cropland (52%), perennial forage (22%), native grassland (9%), wetlands (9%), and aspen (8%). The 379,514 wetland basins in the watershed covered a total of 96,025 hectares. With respect to wetland area, 75.7 % of the wetland hectares were found to be intact, while 15% had been degraded due to cultivation and 9.4% had been lost due to drainage. Lost/destroyed wetlands are defined as those wetlands that are no longer hydrologically capable of holding water. Wetland loss data from the inventory indicates that wetland loss in the Lower Souris River Watershed is under-estimated by at least 5% in Figure 108, and should actually fall in the moderate category. Regional variability in wetland loss can be partially attributed to the local topography, soil type, land-use, climate, , and the form of wetlands in the watershed. Expert opinion suggests that wetland loss in the Lower Souris River Watershed is lower relative to some other watersheds. Therefore, Figure 108 likely significantly underestimates wetland loss for watersheds with greater drainage activity (i.e. the Assiniboine River, Quill Lakes, Wascana Creek, Upper Qu'Appelle River, and Upper Souris River Watersheds). Additional inventories or robust sub-sampling in other watersheds would further refine the estimates used in Figure 108.

Indicator						
Estimated Wetland Drainage	=	(1) Environment Canada PHJV average wetland loss estimates (Watmough et al. 2002) (Category 1-5)	-	(2) Saskatchewan Watershed Authority Licensed Drainage, Drainage Complaints, and Backflood Drainage data by Rural Municipality (Category 1-5)	+	(3) Ducks Unlimited Fall Habitat Transect Survey data by Rural Municipality (Category 1 – 5)

This indicator is a compilation of data sets related to wetland drainage (see **Data Source** on page 101).

General Decision Rules

a) Where the categories for all three datasets are equal, the wetland loss estimate is equal to dataset (1).
b) Where the categories for dataset (2) and (3) are equal, but differ from the category for dataset (1), the wetland loss estimate is adjusted by the number of categories equal to the differences in datasets (2) and (3).
c) Where the categories for dataset (2) and (3) are not equal and differ from the category for data-set (1), the wetland loss estimate is adjusted by the number of categories equal to the mean difference in categories between datasets (2) and (3).

Rating Scheme
Insufficient data from appropriate scientific studies existed to rate this indicator, so, the Jenks' optimization method was used to find the natural breaks in the data.

Wetland Loss
Low intensity: Wetland loss is less than 5%.
Moderate intensity: Wetland loss is between 5% and 9%.
High intensity: Wetland loss is 10% or greater.

Methods: The method used to calculate the Wetland Loss Indicator has been revised from the one used to calculate the Wetland Loss Indicator in the 2007 *State of the Watershed Report*. In the 2007 *State of the Watershed Report*, the data used to calculate the watershed wetland loss values were customized (Watmough 2006) from those obtained from the Enviornment Canada Prairie and Northern Habitat Monitoring Program. In this report the wetland loss values by watershed are calculated by using the wetland loss estimates from Environment Canada's Prairie Joint Venture Habitat Monitoring Program (Watmough et al. 2002) and modifying these wetland loss estimates to include information on drainage; Ducks Unlimited Canada's Fall Habitat Transect Survey data; and expert opinion from Saskatchewan Watershed Authority's regional office staff and Ducks Unlimited Canada's field office staff.

Data Source: This indicator was developed by the Saskatchewan North American Waterfowl Management Plan (NAWMP) Implementation Committee as an indicator of wetland loss for the revision of the Saskatchewan NAWMP Implementation Plan. Data sets used to create this indicator include information from: Environment Canada's Prairie Habitat Joint Venture (PHJV) Habitat Monitoring Program average wetland loss estimates by transect centeroid, interpolated across Saskatchewan by rural municipality (Watmough et al. 2002); the Saskatchewan Watershed Authority's Conservation Authority boundaries; the Saskatchewan Watershed Authority's Licensed Drainage and Backflood Drainage occurrences by RM from the Licensed Drainage and Backflood Drainage Databases and drainage complaints (obtained from regional offices); expert opinion from Saskatchewan Watershed Authority's regional office staff and Ducks Unlimited Canada's field office staff; and Ducks Unlimited Canada's Fall Habitat Transect Survey data.

Data Handling: The interpolated Environment Canada data by transect centroid (Watmough et al. 2002) was used as the baseline from which to start.

Data Discussion: In Saskatchewan's 2007 State of the Watershed Report we used customized data from the Environment Canada Prairie and Northern Habitat Monitoring Program (Watmough et al. 2002 and 2006). To refine the interpolation issues associated with the Watmough (2002) data we incorporated the Saskatchewan Watershed Authority Licensed Drainage, Drainage Complaints, and Backflood Drainage data by Rural Municipality and Ducks Unlimited Fall Habitat Transect Survey data by Rural Municipality.

Response to the issue
In 1995, the Saskatchewan Wetland Policy, implemented by provincial government departments and agencies and led by the Saskatchewan Watershed Authority, was approved. The policy promotes the "sustainable management of wetlands on public and private lands" (Lynch-Stewart et al. 1999) (see **Legislative Tools, Strategies, Policies and Guidelines** in Appendix C).

Saskatchewan is a partner of the North American Management Plan (NAWMP). The NAWMP is an agreement between the United States, Canada and Mexico to conserve wetland and upland habitat for the promotion of migratory bird populations. To deliver the NAWMP in Canada's three Prairie Provinces, the Prairie Habitat Joint Venture (PHJV) was established. The PHJV involves over 340 conservation partners, and as of January 2006, these partners had secured/influenced 1.9 million hectares of wetland and upland habitat. A total of 1.2 million of these 1.9 million hectares were secured after 1986 (Prairie Habitat Joint Venture 2006).

The National Round Table on the Environment and the Economy (NRTEE), in partnership with Statistics Canada, Natural Resources Canada – Canada Centre for Remote Sensing, the Canadian Space Agency and Environment Canada, is in the process of developing an indicator to measure the extent of wetlands in Canada. However, the current data limitations prevent a national overview of wetlands due to insufficient national coverage, and inconsistent time lines and data collection standards (National Round Table on the Environment and the Economy 2003). This NRTEE-led effort to begin a wetland inventory for Canada would contribute significantly to Saskatchewan's wetland knowledge base.

Some of the recent wetland drainage assessments/studies that have been conducted on watersheds in Saskatchewan include:

- To quantify the impacts of wetland drainage and increased cultivation on native vegetation and surface water quantity between 1974 and 2002 in the Conservation and Development Authority of St. Gregor South, Ducks Unlimited Canada initiated a change detection analysis in 2002 (Boychuk and Thibault 2003).
- In the spring of 2007, high water levels and high flows were experienced in a number of lakes and streams within central and eastern Saskatchewan. In response, the Saskatchewan Watershed Authority initiated an assessment to determine the impacts wetland drainage was having on high water levels in the Waldsea, Deadmoose, Houghton, and Fishing Lake Watersheds (Saskatchewan Watershed Authority 2008c). The drainage assessment identified:
    - the extent of drainage in the Fishing Lake and Waldsea Lake watersheds;
    - the impact of current drainage on lake inflow volumes and peak water levels in the Fishing Lake and Waldsea Lake watersheds;
    - the impact of drainage on frequency of outflow and outflow volume from Fishing Lake;
    - the effect of closing the Brockman Slough Diversion into Waldsea Lake; and
    - mitigation options for the Fishing Lake and Waldsea Lake watersheds (Saskatchewan Watershed Authority 2008d).

- Two wetland drainage studies in the Smith Creek Watershed have been initiated by the Centre for Hydrology at the University of Saskatchewan. One study is assessing the impacts of wetland drainage on water quantity, and the other study is assessing the impacts of wetland drainage on water quality.
  - The water quantity study was initiated in 2007. The objective of the study is to develop a Prairie Hydrological Model. Some of the activities associated with the water quantity study include:
    1) Creating a hydrological model (the Prairie Hydrological Model), suitable for simulating multiple seasons of the hydrology of the Canadian Prairie environment. The model will be capable of predicting water balance, soil moisture, snow cover, actual evaporation, and streamflow on a daily time-step, with minimal calibration of model parameters from streamflow records.
    2) Examining the impacts of wetland drainage on streamflows and other meteorological variables in the basin.
    3) Estimating the volume of water storage in some of the basin's wetlands.
    4) Simulation of wetland drainage scenarios and land use changes on hydrological variables, including steamflows.
  - The water quality study was initiated in 2008 in collaboration with the Saskatchewan Watershed Authority. The main goal of the project is to assess the impact of wetland drainage on surface water quality in the prairies. Some of the activities of the water quality study include:
    1) Characterizing wetland water quality (among intact wetlands) to determine if wetlands of different land uses, permanence categories and position in the ground water system have different chemical characteristics.
    2) Assessing whether water quality along man-made (artificial) drains differs from the water quality along natural drains.
    3) Conducting a wetland drainage experiment wherein the water quality in a wetland was measured weekly for a period of 20 weeks during 2008. A drain was then built in October 2009 and the water quality was measured at several sites along the drain to examine outputs.
    4) Characterizing stream water quality across the basin.

Ducks Unlimited Canada, the Saskatchewan Watershed Authority, Agriculture and Agri-Food Canada, the Saskatchewan Ministry of Agriculture, the Saskatchewan Ministry of Environment, Environment Canada, and the Nature Conservancy of Canada, as well as other non-government organizations, have information and programs related to wetland conservation and restoration.

It is recognized that this current indicator has limitations, and will be improved upon in future *State of the Watershed Reports*.

Natural Resource Extractions

Oil and Gas Spills Indicator

The Oil and Gas Spills Indicator was designed to identify the intensity of oil and gas spills at a watershed scale. Three rating schemes are employed: one to assess the relative densities of oil and spills among watersheds; the second to assess the relative volume of oil and emulsion spills among watersheds; and the third to assess the relative volume of salt water spills among watersheds.

Indicator	
Annual Density of Oil and Gas Spills	**Status:** Oil and gas activity continues to increase in Saskatchewan. The method used to calculate reported oil and gas spills by watershed was revised from that found in the Oil and Gas Indicator in the 2007 *State of the Watershed Report*. In the 2007 *State of the Watershed Report*, the indicator was based on the total number of reported oil and gas spills between 1993 and 2003. In this report, the average annual reported oil and gas spills by watershed within the two time frames (1993-2003 and 2004-2007) are compared instead. **Trend:** The average annual number of reported oil and gas spills by watershed remained relatively constant between 1993-2003 and 2004-2007.
Annual Volume of Oil and Emulsion Spills	**Trend:** The average annual volume of reported oil and emulsion spills decreased between 1993-2003 and 2004-2007.
Annual Volume of Salt Water Spills	**Trend:** There was a decrease in the average annual volume of reported salt water spills between 1993-2003 and 2004-2007.

The issue

The upstream oil and gas industry is involved in the exploration, refinement, and transportation of crude oil and natural gas. In 2004, Saskatchewan's upstream oil and natural gas industry produced 24 million cubic metres of crude oil and 8,341 million cubic metres of natural gas (Saskatchewan Ministry of Energy and Resources 2008a, 2008b). By the end of 2007 there were 40,186 wells capable of oil production in Saskatchewan, of which 24,948 were actively producing. There were also 19,531 actively producing natural gas wells in the province. Saskatchewan is the second largest crude oil producer in Canada, accounting for approximately 18% of Canada's oil production, and it is the third largest natural gas producer in Canada (Canadian Association of Petroleum Producers 2006; Saskatchewan Ministry of Energy and Resources 2008c, 2008d).

Oil and gas exploration and development in Saskatchewan has the potential to impact watershed health in a number of ways, including: spills; wastewater disposal; leaching of surface discharge; stormwater runoff from well sites; surface water and ground water extraction; leaking of transport pipelines and underground storage; emission of acidifying compounds; production of greenhouse gas emissions; and alteration of terrestrial and aquatic wildlife habitat and biodiversity caused by the aforementioned activities (Confluence Consulting Inc. 2004).

The two watersheds with the highest density of active oil wells in Saskatchewan are the Eagle Creek and Upper Souris River Watersheds, which each have more than 6,000 active oil wells. The Cypress Hills North Slope and South Saskatchewan River Watersheds, meanwhile, have the highest density of active gas wells, with over 7,000 and 9,000 gas wells, respectively (Saskatchewan Ministry of Energy and Resources 2009a).

Provincially, regulations ensure that operations incorporate multiple built-in containment and protection systems to ensure there is little or no impact to the air, land and water. However, it is important to have indicators that measure the intensity and potential risk of upstream oil and gas activities.

Oil and Gas Indicator in Saskatchewan

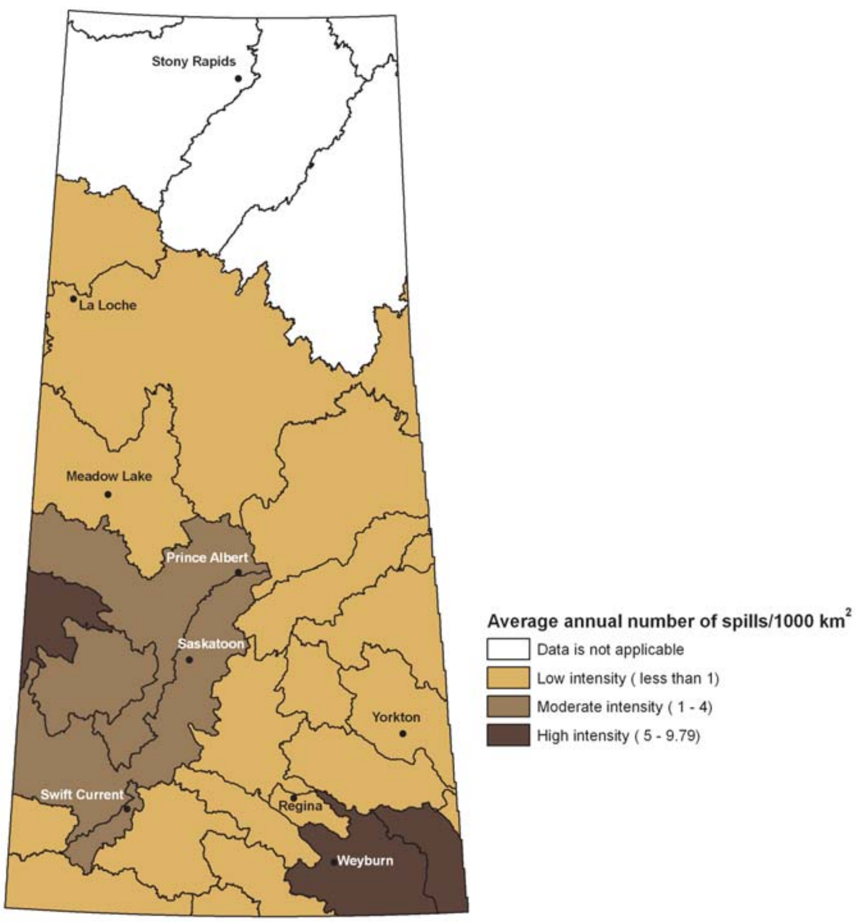

Figure 109. Average annual number of reported oil and gas spills per 1,000 km^2 by watershed: 2004-2007.

By 2007, oil and gas activity was occurring in 24 of Saskatchewan's 29 watersheds. With respect to the average annual number of reported oil and gas spills, 17 of these watersheds are classified as low intensity, four are classified as moderate intensity, and three are classified as high intensity (Figure 109).

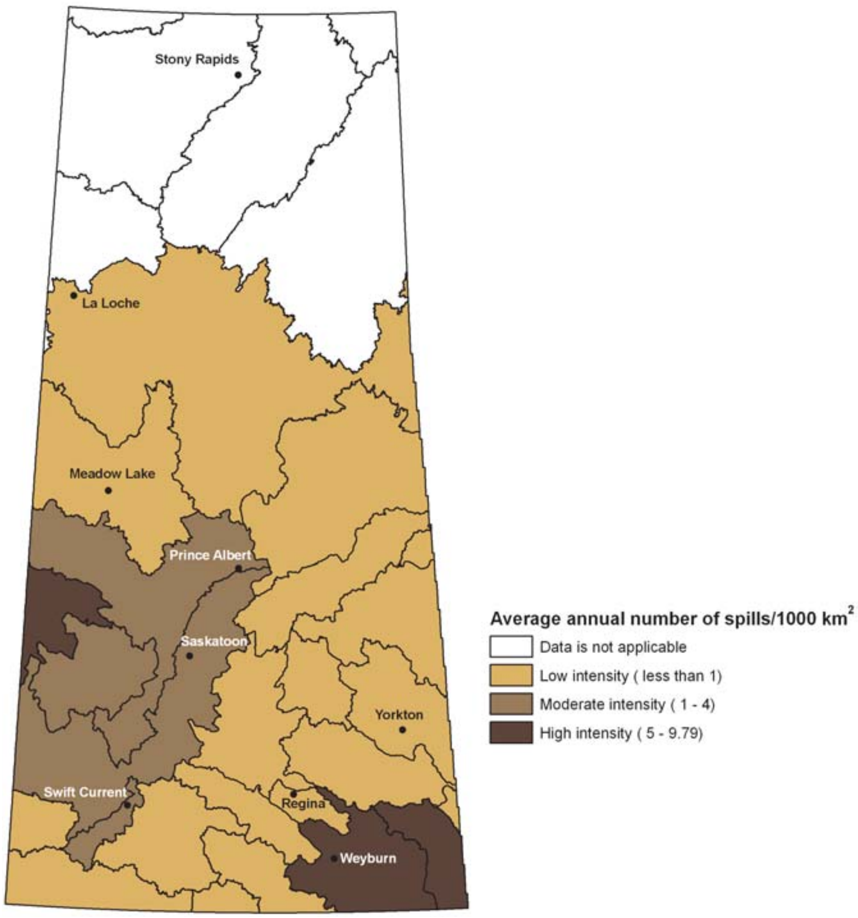

Figure 110. Average annual number of reported oil and gas spills per 1,000 km^2 by watershed: 1993-2003.

Between 1993 and 2003, oil and gas activity was occurring in 23 of Saskatchewan's 29 watersheds. With respect to the average annual number of reported oil and gas spills, 17 of these watersheds are classified as low intensity, four are classified as moderate intensity, and three are classified as high intensity (Figure 110).

The average annual number of reported oil and gas spills by watershed between 1993-2003 and 2004 -2007 remained relatively constant. Of the 23 watersheds that were classified in both of these time periods, all watersheds were classified in the same intensity level for both Figures 109 and 110.

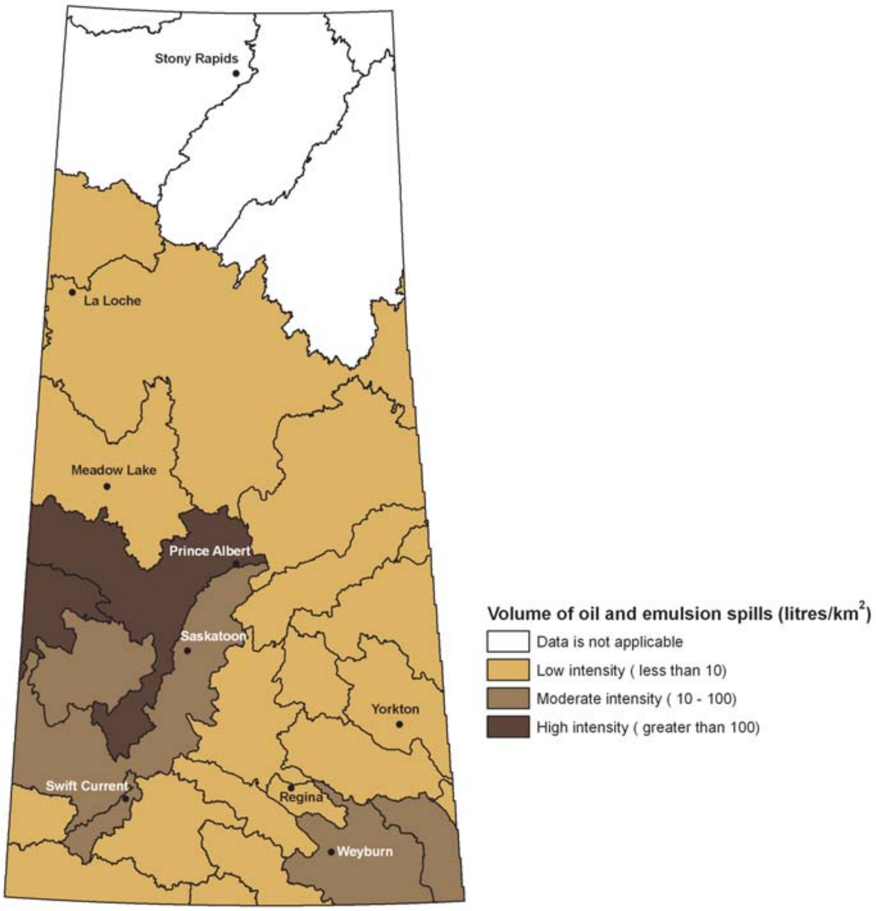

Figure 111. Average annual volume of reported oil and emulsion spills per square kilometre by watershed: 2004-2007.

Of the 24 watersheds classified in Figure 111, 17 watersheds are classified as low intensity, five are classified as moderate intensity, and the Battle River and North Saskatchewan River Watersheds are classified as high intensity.

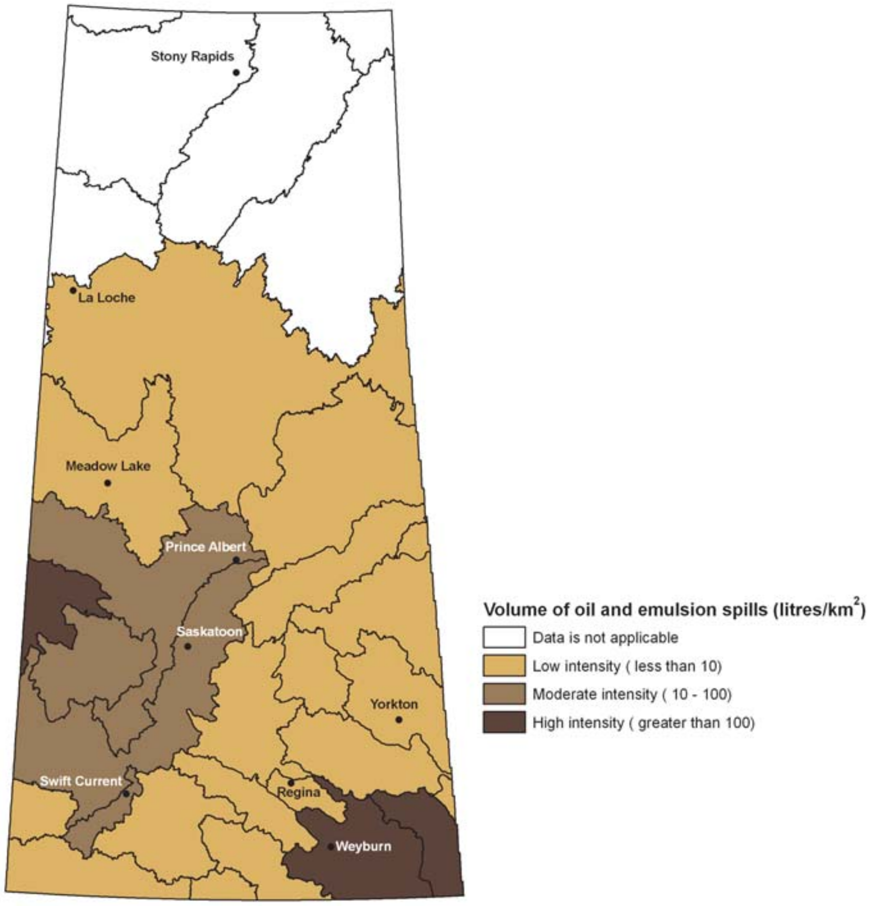

Figure 112. Average annual volume of reported oil and emulsion spills per square kilometre by watershed: 1993-2003.

Of the 23 watersheds classified in respect to the average volume of oil and emulsion spills in Figure 112, 17 are classified as low intensity, four are classified as moderate intensity, and three are classified as high intensity (Figure 112).

The Battle River Watershed was the only watershed that was classified as high intensity in both Figures 111 and 112. The average annual volume of oil and emulsion spills in the North Saskatchewan River Watershed increased between 1993-2003 and 2004-2007. The average annual volume of oil and emulsion spills decreased in the Lower Souris River and Upper Souris River Watersheds within this same time period. Overall, the average annual volume of oil and emulsion spills decreased between 1993-2003 (Figure 112) and 2004-2007 (Figure 111).

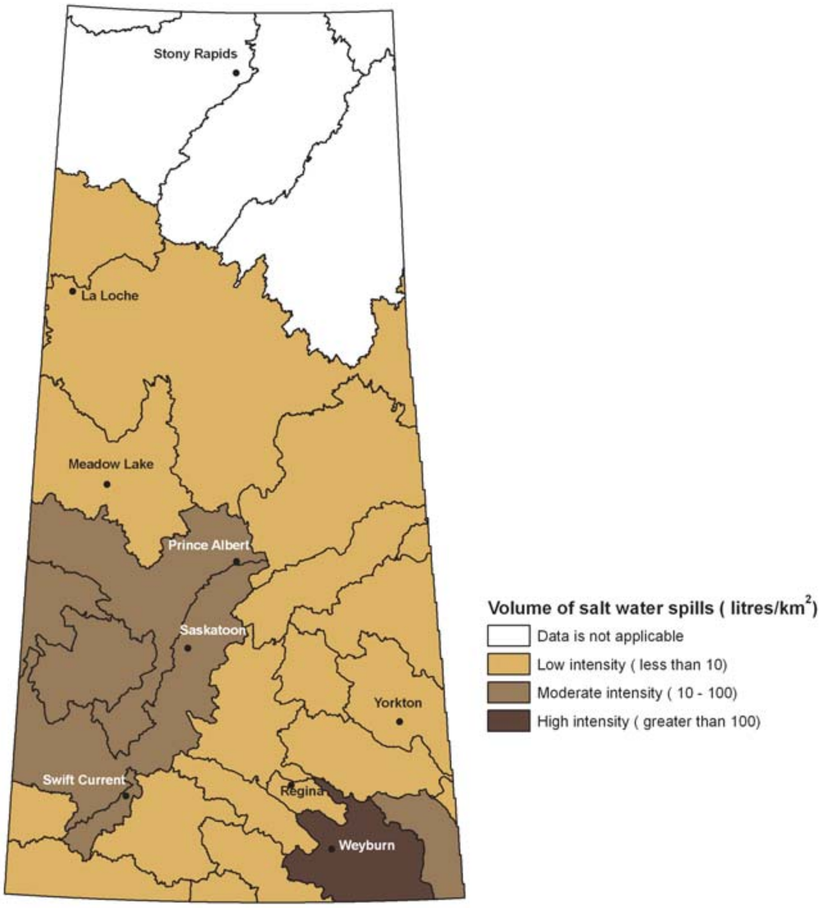

Figure 113. Average annual volume of reported saltwater spills per square kilometre by watershed: 2004-2007.

Of the 24 watersheds with oil and gas activity, 17 are rated as low intensity, six are rated as moderate intensity, and the Upper Souris River Watershed is rated as high intensity.

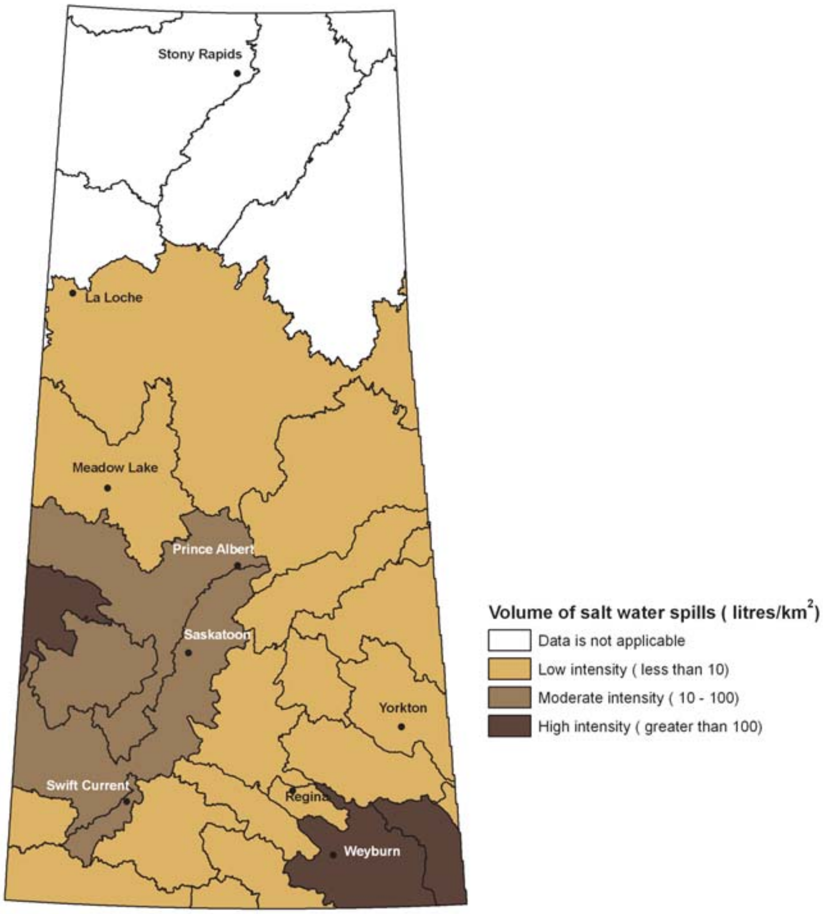

Figure 114. Average annual volume of reported saltwater spills per square kilometre by watershed : 1993-2003.

Of the 23 watersheds with oil and gas activity, 17 watersheds are classified as low intensity, four are classified as moderate intensity, and three are classified as high intensity (Figure 114).

The average annual volume of reported saltwater spills per square kilometre decreased in the Battle River and Lower Souris River Watersheds between 1993-2003 and 2004-2007. For all other watersheds, the average annual volume of reported saltwater spills per square kilometre remained the same between these two time periods. Overall, there was a decrease in the average annual volume of salt water spills per square kilometre between 1993-2003 (Figure 114) and 2004-2007 (Figure 113).

Indicator		
Average Annual Density of Oil and Gas Spills	=	$\frac{\text{Average annual number of oil and gas spills}}{\text{Total watershed area (km}^2\text{)}}$
Average Annual Volume of Oil and Emulsion Spills per Square Kilometre	=	$\frac{\text{Average annual volume of oil and emulsion spills (litres)}}{\text{Total watershed area (km}^2\text{)}}$
Average Annual Volume of Saltwater Spills per Square Kilometre	=	$\frac{\text{Average annual volume of saltwater spills (litres)}}{\text{Total watershed area (km}^2\text{)}}$

Note: Upstream oil and gas spills are spills of unrefined products, such as crude oil, natural gas and condensates.

Rating Scheme
Insufficient data from appropriate scientific studies existed to rate this indicator, so the Jenks' optimization method was used to find the natural breaks in the data.

Average Annual Density of Oil and Gas Spills
Low intensity: The average annual number of oil and gas spills is less than 1 spill/1,000 km^2.
Moderate intensity: The average annual number of oil and gas spills is between 1 and 4 spills/1,000 km^2.
High intensity: The average annual number of oil and gas spills is equal to or greater than 5 spills/1,000 km^2.

Average Annual Volume of Oil and Emulsion Spills per Square Kilometre
Low intensity: The average annual volume of oil and emulsion spills is less than 10 litres/km^2.
Moderate intensity: The average annual volume of oil and emulsion spills is between 10 and 100 litres/km^2.
High intensity: The average annual volume of oil and emulsion spills is greater than 100 litres/km^2.

Average Annual Volume of Saltwater Spills per Square Kilometre
Low intensity: The average annual volume of saltwater spills is less than 10 litres/km^2.
Moderate intensity: The average annual volume of saltwater spills is between 10 and 100 litres/km^2.
High intensity: The average annual volume of saltwater spills is greater than 100 litres/km^2.

Methods: The method used to calculate reported oil and gas spills by watershed was revised from that used for the Oil and Gas Indicator in the 2007 *State of the Watershed Report*. In this report, the average annual reported oil and gas spills by watershed within the two time frames (1993-2003 and 2004-2007) are compared to each other, whereas in the 2007 *State of the Watershed Report* the indicator was based on the total number of reported oil and gas spills between 1993 and 2003.

Data Source: The number and volume of reported oil and gas spills in Saskatchewan was obtained from the Saskatchewan Ministry of Energy and Resources' Upstream Oil and Gas Sites Spill Database. Please note that not all spills are reported and that spills less than 1.6 cubic metres are not reported, and as such are not included in the Upstream Oil and Gas Sites Spill Database.

Data Handling: The Saskatchewan Ministry of Energy and Resources' database contains information on oil and gas spills between 1991 and 2007.

Data Quality/Caveats: Upstream oil and gas spills are spills of unrefined products, such as crude oil, natural gas and condensates. The Oil and Gas Spill Indicator estimates the relative intensity of an upstream oil and gas spill. Figures 111, 112, 113, and 114 are based on the reported volume of spills and do not take into account the amount of materials recovered from the spill. On average, 71% of oil and emulsion spills and 54% of saltwater spills are recovered. Please note that not all spills are reported and that spills less than 1.6 cubic metres are not reported, and as such are not included in the Upstream Oil and Gas Sites Spill Database.

Response to the issue

The exploration, refinement, and transportation of crude oil and natural gas within Saskatchewan is regulated by: *The Mineral Resources Act, 1985, The Oil and Gas Conservation Act, The Oil and Gas Conservation Regulations, 1985,* and *The Seismic Exploration Regulations, 1999*, administered by the Saskatchewan Ministry of Energy and Resources; and *The Hazardous Substances and Waste Dangerous Goods Regulations* and *The Environmental Spill Control Regulations* under *The Environmental Management and Protection Act, 2002*, administered by the Saskatchewan Ministry of Environment.

In addition to legislation, the Saskatchewan Ministry of Energy and Resources administers a number of guidelines related to spills, contaminated sites and waste disposal from upstream oil and gas operations. These include: the Spill Site Reclamation Guidelines**;** the Upstream Contaminated Sites Remediation and Environmental Site Assessment Guidelines; the Drilling Waste Management and Frac Fluid and Sand Disposal Guidelines; and the Interim Draft Industrial Landfilling Requirements for Wastes Generated from Upstream Oil and Gas Industry.

The Saskatchewan Ministry of Environment established the Provincial Enforcement Centre Spill Report Line to receive and record province-wide reports of spills and environmental emergencies. Provincial Enforcement Centre staff can provide advice on reported spills and confirm if containment and cleanup measures are adequate. Any spills reported to Ministry of Energy and Resources are inspected for containment and clean up by the Ministry's Petroleum Development field staff.

Mines Indicator

This indicator looks at the density and potential environmental risk of mines in Saskatchewan by watershed.

Indicator	
Density of Mines	**Status:** There are more than 25 operating mines in Saskatchewan. The method used to calculate the density of mines has been revised from the one used to calculate the density of mines in the 2007 *State of the Watershed Report* (see the **Methods** section on page 117 for details). **Trend:** The increase in density of mines between 2007 and 2009 is not due to an increase in the actual number of mines in the province, but rather a better understanding of the mines and the inclusion of gravel pits in Saskatchewan.
Potential Environmental Risk of Mines	**Trend:** The increase in potential risk associated with mines between 2007 and 2009 is not due to an increase in the potential risk of mines, but rather a better understanding of the mines and the inclusion of gravel pits in Saskatchewan.

The issue
Mining is an important sector of Saskatchewan's economy. However, activities associated with mining can affect watershed health. These activities include habitat fragmentation from roads, localized ecosystem disruption, the release of air- and water-borne chemicals into the environment, the increase of surface water temperature, and altering the flow characteristics of rivers. Retired or abandoned mine sites can also pose significant physical and/or environmental hazards, notably through acid mine drainage from mine tailings or deposits. Acid mine drainage is caused by the metabolic activity of the bacterium *Thiobacillus ferrooxidans*, which oxidizes iron and inorganic sulphur compounds found in mine tailings and coal deposits.

Mines in Saskatchewan produce many commodities, including bentonite, clay, coal, gold, kaolin, lignite, potassium sulphate, potash, salt, silica sand, sodium sulphate, and uranium. Some of the mining projects presently being developed in Saskatchewan are exploring the production of diamonds, magnesium sulphate and graphite (Saskatchewan Ministry of Energy and Resources 2009b).

Mine Indicator in Saskatchewan

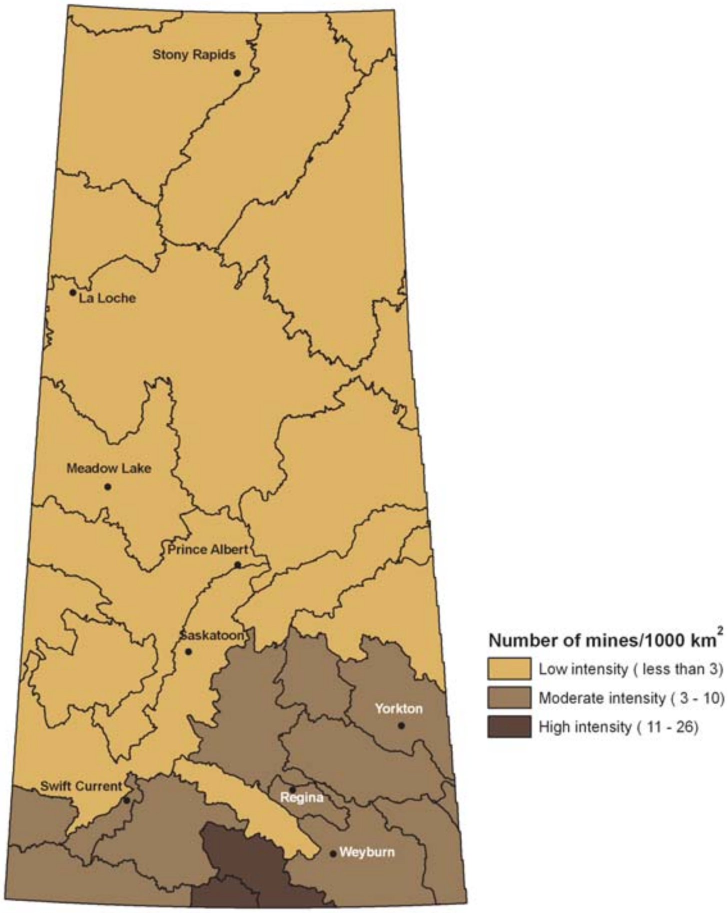

Figure 115. Density of active, inactive and abandoned mines.

Density of mines is rated as low intensity for 16 watersheds, moderate for 11 watersheds and high intensity for the Big Muddy and Poplar River Watersheds. Of the mines in Saskatchewan, 61% are gravel pits, 35% are abandoned mines, and 2% are active mines. The abandoned mines include coal mines (79%), uranium mines (8%) and other types of mines (13%). The majority of the mines are in the southern part of the province.

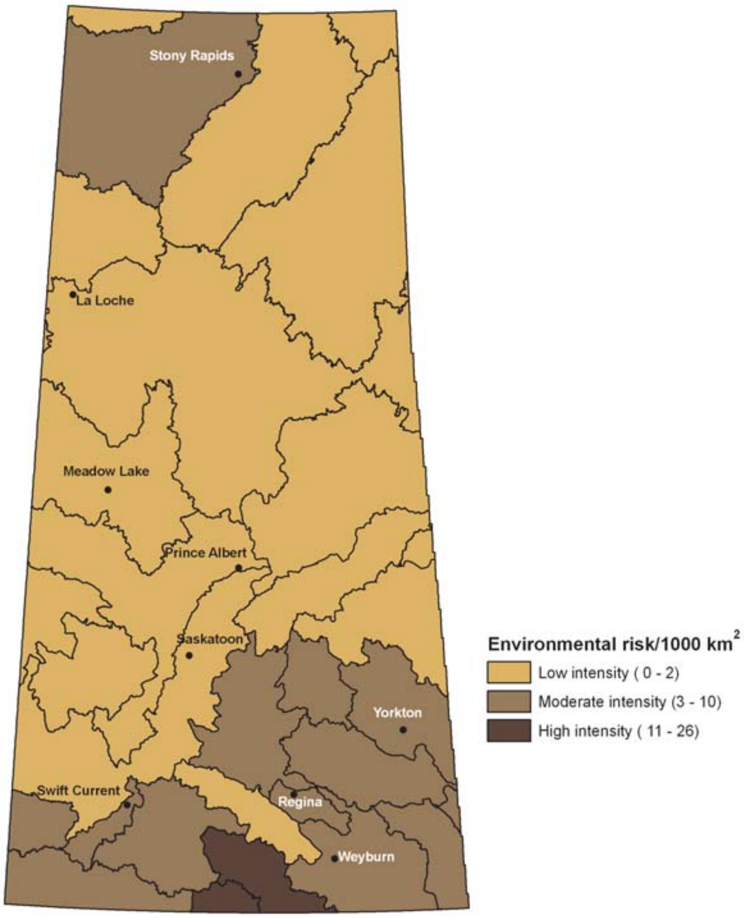

Figure 116. Environmental stress of active, inactive and abandoned mines.

The environmental stress is rated as low intensity for 15 watersheds, moderate for 12 watersheds and high intensity for the Big Muddy and Poplar River Watersheds. The majority of mines are in the southern part of the province. However, the potential environmental risk is greater for some of the northern uranium mines.

Indicator		
Density of Mines	=	Number of active, inactive and abandoned mines per watershed / Total watershed area (1,000 km^2)
Potential Environmental Stress of Mines	=	[(Number of active, inactive and abandoned mines per watershed) x (Environmental risk class)] / Total watershed area (km^2)

Rating Scheme
Insufficient data from appropriate scientific studies existed to rate this indicator, so the Jenks' optimization method was used to find the natural breaks in the data.

Density of Mines
Low intensity: The density of mines is less than 3/1,000 km^2.
Moderate intensity: The density of mines is between 3 and 10/1,000 km^2.
High intensity: The density of mines is greater than 10/1,000 km^2.

Potential Environmental Risk of Mines
Low intensity: Potential environmental risk of mines by watershed is less than 3/1,000 km^2.
Moderate intensity: Potential environmental risk of mines by watershed is between 3 and 10/1,000 km^2.
High intensity: Potential environmental risk of mines by watershed is greater than 10/1,000 km^2.

Methods: The method used to calculate the Density of Mines Indicator has been revised from the one used to calculate the Density of Mines Indicator in the 2007 *State of the Watershed Report*. In this report, gravel pits are included in the indicator. Gravel pits were not included in the Density of Mines Indicator used in the 2007 report.

The method used to calculate the Potential Environmental Risk of Mines Indicator has been revised from the one used to calculate the Potential Environmental Risk of Mines Indicator in the 2007 *State of the Watershed Report.* In the 2007 *State of the Watershed Report* the number of mines was multiplied by their associated environmental risk class by watershed to get the environmental stress of mines. In this report the indicator is taken a step further and the environmental stress of mines is divided by the area of the watershed.

Data Source: The location and type of active and inactive mines was obtained from the Mining.mine_sites shapefile (an SDE feature class), which is part of the Geological Atlas of Saskatchewan (Saskatchewan Industry and Resources 2004). Information on abandoned mines was obtained from four reference documents: Saskatchewan Environment and Public Safety 1989; (KHS) Environmental Management Group Ltd. 2001; Clifton Associates Ltd. 2002; and Clifton Associates Ltd. 2003. Additional information on abandoned mines was obtained from the Mining.Mine_location shapefile, an SDE feature class which was created by the Saskatchewan Ministry of Environment and has been updated on an ongoing basis since 2006. Gravel pit location information was obtained from the Saskatchewan Ministry of Highways and Infrastructure (2008).

Data Handling: The environmental stress classes were calculated using a number of criteria. The environmental stress classes were based on the type of mines, where: copper, zinc, gold, nickel, and uranium mines were considered higher risk = 3; potash, potash/salt, potassium sulphate, salt and sodium sulphate mines were considered moderate risk = 2; and bentonite, clay, coal, silica sand, stone and peat mines were considered lower risk = 1.

Response to the issue
Mining operations are regulated in Saskatchewan by: *The Mineral Resources Act, 1985* and *The Seismic Exploration Regulations, 1999*, administered by the Saskatchewan Ministry of Energy and Resources; *The Mineral Industry Environmental Protection Regulations, 1996*, administered by the Saskatchewan Ministry of Environment; and the *Metal Mining Effluent Regulations* and guidelines, administered under the *Fisheries Act*.

To promote best management practices for mineral exploration, the Saskatchewan Mineral Exploration and Government Advisory Committee (SMEGAC) developed the *Mineral Exploration Guidelines for Saskatchewan* (Saskatchewan Mineral Exploration and Government Advisory Committee 2005). These guidelines provide information on best management practices to assist proponents in reducing the environmental impacts of planning, initiating and completing a mineral exploration program.

When applying for a Mine Operating License, all new mining projects are required to provide reclamation and decommissioning plans as part of their Environmental Impact Assessment Statement that is submitted to the Saskatchewan Ministry of Environment. As part of the Mine Operating License, all mines must provide financial security for decommissioning and reclamation costs. These provisions are outlined in both *The Environmental Management and Protection Act, 2002* and *The Environmental Assessment Act.*

To assess the impacts of mining operations on water quality, a number of water quality monitoring programs have been initiated:

- The National Environmental Effects Monitoring Program is a requirement for all metal mines under the *Metal Mining Effluent Regulations*, as contained in the *Fisheries Act*. The National Environmental Effects Monitoring Program consists of a number of monitoring surveys, including:
  - *the Fish Survey* (biological monitoring survey);
  - *the Benthic Invertebrate Community Survey* (biological monitoring survey);
  - *Fish Usability* (biological monitoring survey);
  - *Alternative Monitoring Methods*;
  - *Sublethal Toxicity Testing*; and
  - *Environmental Supporting Variables*.
- The Saskatchewan Ministry of Environment's Cumulative Effects Monitoring Program has been collecting samples in northern Saskatchewan since 1994. The program collects water, sediment, aquatic macrophyte, and fish tissue samples from class effects and regional effects sampling stations once a year on a three-year rotation.
- The Athabasca Working Group's Environmental Monitoring Program was initiated in 2000 as a joint community-based environmental monitoring program between three uranium mining companies (Cameco Corporation, AREVA Resources Canada Inc. (previously COGEMA) and Cigar Lake Mining Corporation) and seven communities (Wollaston Lake, Hatchet Lake, Black Lake, Stony Rapids, Fond-du-Lac, Uranium City, and Camsell Portage). The program collects and analyzes water, fish, vegetation, animal, and radon gas samples to assess the environmental impact related to uranium mining.

In the late 1980's, the Saskatchewan Ministry of Environment (previously Saskatchewan Environment and Public Safety) established the Abandoned Mines Remedial Action Program to identify all of the abandoned mining operations in Saskatchewan. Due to budget constraints, the project was terminated in the early 1990's. In 2000, through funding from the Province of Saskatchewan's Centenary Fund, Saskatchewan Environment and Saskatchewan Energy and Resource Management (SERM) initiated the Abandoned Mines Assessment Program. The purpose of this program was to assess the identified abandoned mine sites in northern Saskatchewan and prioritize these sites based on risk to public safety and environmental concerns. Through this program, consulting companies assessed 75 mine sites in northern Saskatchewan between 2000 and 2002. In year two and three of this program, the acid mine drainage potential was also recorded. The information collected during this program has been compiled into three documents: [(KHS) Environmental Management group Ltd. 2001; Clifton Associates Ltd. 2002; and Clifton Associates Ltd. 2003].

Forest Disturbance Indicator

This indicator measures the disturbance of forested area caused by forestry activities and wildfire in Saskatchewan by watershed.

Indicator	
Forest Disturbance	**Status:** Forestry activities have decreased in Saskatchewan in recent years due to market conditions. The method used to calculate the Forest Disturbance Indicator has been revised from the one used to calculate the Forestry Indicator in the 2007 *State of the Watershed Report* (see the **Methods** section on page 123 for details). **Trend:** There was no trend observed in the disturbance of forested area between the two 14 year time periods (1980-1993 and 1994-2007).

The issue

Disturbance of forested areas caused by activities such as harvesting, road construction, wildfires, and insect/disease outbreaks can potentially impact both aquatic and terrestrial ecosystems. Forestry activities can impact ecosystems by: increasing soil erosion; increasing nutrient and ion loading; increasing organic debris; changing temperature regimes; fragmenting habitat; introducing invasive species; and increasing or decreasing streamflow. An investigation conducted by Pomeroy et al. (1997) on the hydrological processes in the southern boreal forest found that snowmelt occurs up to three times faster in harvested areas compared to mature stands. The faster snowmelt and increased runoff from these harvested areas resulted in less infiltration to ground water and increased peak runoff.

Wildfires are also a common disturbance in boreal forests. Wildfires are a natural part of boreal forest succession and can have both positive and negative effects on the surrounding terrestrial and aquatic ecosystems. Some of the potential environmental impacts of fires include: the destruction of old, diseased trees and associated pests; stimulating fire dependent trees, such as jack pine, to reproduce; causing habitat change; increasing temperature, ash, nutrients, sediment and turbidity in aquatic ecosystems.

There are approximately 34 million hectares of provincial forests (commercial and non-commercial) in Saskatchewan, covering 52% of the province (Saskatchewan Ministry of Environment 2008a). The Saskatchewan Ministry of Environment currently manages 12 million hectares (37%) of provincial forests for the licensed harvest of forest products (Saskatchewan Ministry of Environment 2008b).

In the last few years, the forestry sector in Saskatchewan has struggled with job losses and mill shutdowns. This economic slowdown is due to a number of factors, including:

- general economic conditions related to the industry;
- low housing starts in the United States;
- competition from lower-cost pulp processed in South America and Asia; and
- The Softwood Lumber Agreement with the United States, which restricts the exports of Saskatchewan lumber to the US (Saskatchewan Forestry Centre 2007).

Forest Disturbance Indicator in Saskatchewan

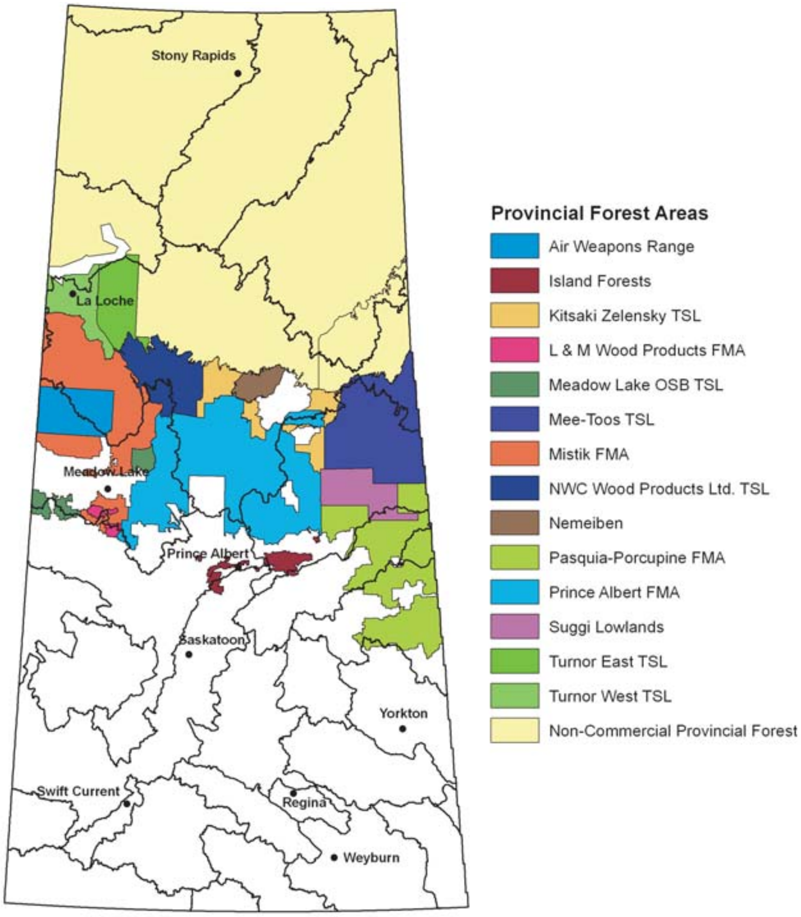

Figure 117. Saskatchewan commercial provincial forest areas.

Saskatchewan's commercial provincial forest area overlaps 10 watershed boundaries. The ten watersheds that contain a portion of the commercial forest area include: the Assiniboine River Watershed (less than 1% of the commercial forest area); the Athabasca River Watershed (1%), the Beaver River Watershed (13%), the Carrot River Watershed (4%), the Churchill River Watershed (45%), the Lake Winnipegosis Watershed (7%), the North Saskatchewan River Watershed (2%), the Reindeer/Wollaston Lake Watershed (5%), the Saskatchewan River Watershed (23%) and the South Saskatchewan River Watershed (less than 1%).

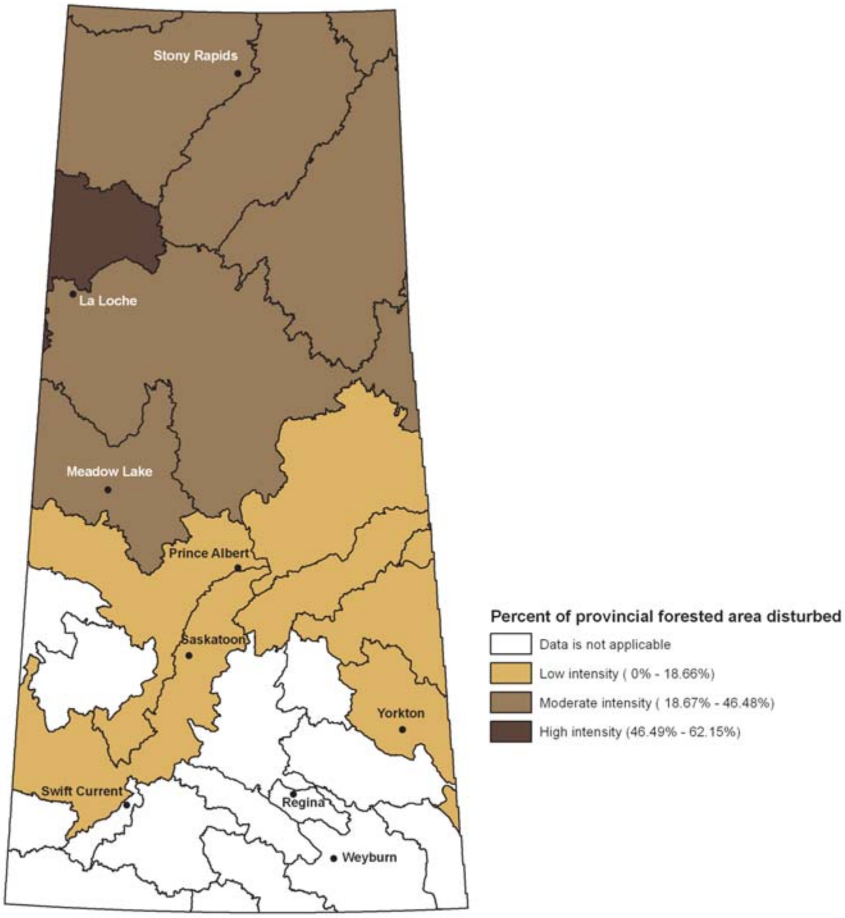

Figure 118. Percent of forested area disturbed: 1994-2007.

Between 1994 and 2007, disturbance (harvest and burn) information was available for 14 watersheds. The percent of forested area disturbed during this period is classified as low intensity for seven watersheds, moderate intensity for seven watersheds and high intensity of the Athabasca River Watershed. During this time, period forest fires accounted for 97% of the disturbance, while the remaining 3% of the disturbance was attributed to harvesting.

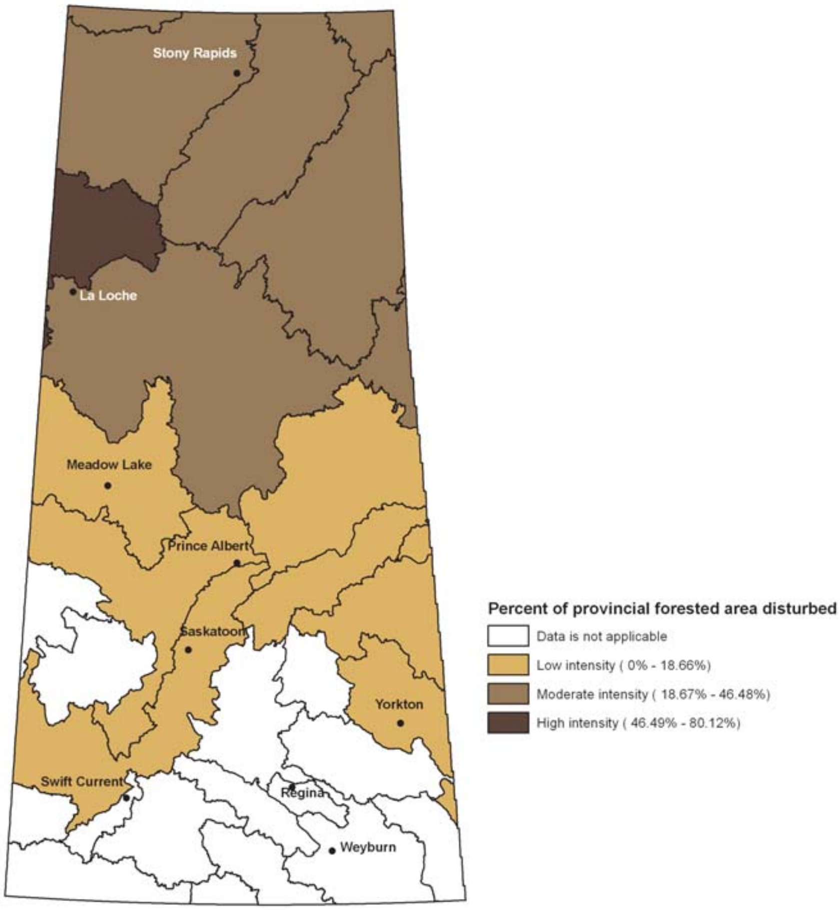

Figure 119. Percent of forested area disturbed: 1980-1993.

Between 1980 and 1993, disturbance (harvest and burn) information was available for 14 watersheds. The percent of forested area disturbed is classified as low intensity for seven watersheds, moderate intensity for six watersheds, and high intensity for the Athabasca River Watershed. During this time period, forest fires accounted for 99% of the disturbance, while the remaining 1% of the disturbance was attributed to harvesting.

Ratings for 13 of the 14 watersheds that had data available for both 1980-1993 and 1994-2007 were the same in both Figures 118 and 119. The only watershed which showed a change between the two time periods is the Beaver River Watershed, which was classified as low intensity in Figure 119 and moderate intensity in Figure 118.

Indicator			
Percent of Forested Area Disturbed in the Last 14 Years	=	$\frac{\text{Disturbed forested area (ha)}}{\text{Forested area within the watershed (ha)}}$	x 100

Rating Scheme
Insufficient data from appropriate scientific studies existed to rate this indicator, so the Jenks' optimization method was used to identify the natural breaks in the data.

Percent of Forested Area Disturbed in the Last 14 Years
Low intensity: Percent of forested area disturbed is less than 18.67%.
Moderate intensity: Percent of forested area disturbed ranges from 18.67% to 46.48%.
High intensity: Percent of forested area disturbed is greater than 46.48%.

Methods: The method used to calculate the Forest Disturbance Indicator has been revised from the one used to calculate the Forestry Indicator in the 2007 *State of the Watershed Report*. In the 2007 *State of the Watershed Report* indicator was based on the percent of forested area disturbed in the last 20 years. In this report, the indicator is calculated using the percent of forested area disturbed in the last 14 years, as harvested areas can regenerate naturally or artificially within this timeframe.

Data Source: The disturbance type and year were obtained from the Saskatchewan Ministry of Environment, Forest Service Branch, based on the following sources:

- downloaded data from the virtual data warehouse as major data sources;
- submitted by forest management agreement (FMA) holders (Domtar and Weyerhaeuser) as supplemental sources; and
- created by the Forest Service Branch as supplemental sources.

The historic harvest data was created by both industries for FMA areas and the Forest Service Branch for Term Supply Licence areas, based on aerial photography, hand-drawn sketches, GPS coordinates, silviculture regeneration survey results, satellite imagery, and forest inventory. Harvest information for the L&M Wood Products FMA is currently unavailable.

Data Handling: Forest inventory polygon tables were queried to extract any polygon that had a value entered for SA (species association) and/or DIST (disturbance type). This identified any areas that are currently forested or have been forested in the past.

Data Quality/Caveats: Forestry roads are not currently included in this indicator, as information on forestry roads is limited.

Data Discussion: The intention of this indicator is to include and map all of the forested areas that have been disturbed by human activities by watershed. Currently, harvesting and fire are the types of disturbances that are included in Figures 118 and 119.

Response to the issue
Provincial forests are managed in Saskatchewan by the Saskatchewan Ministry of Environment's Forest Service Branch, through the administration of *The Forest Resources Management Act* and Regulations. *The Forest Resources Management Act* and Regulations promote the sustainable management of forested lands through, in part, the protection of watersheds and forests.

In Saskatchewan, a licence is required for the commercial harvesting of forest products within Crown forests. There are three types of licences:

- **Forest Management Agreements** (FMA) - which are 20-year term agreements providing harvest rights for a certain volume of timber from a defined area. There are currently four Forest Management Agreements in the province:
  - L&M Wood Products FMA;
  - Mistik Management FMA;
  - Weyerhaeuser Pasquia-Porcupine FMA; and
  - Prince Albert FMA.

  Specific Forest Management Agreement Area Standards and guidelines have been developed for each of the FMAs.
- **Term Supply Licences -** which are not to exceed ten years, provide volume or area-based harvest rights for specified forest products, and define management responsibilities.
- **Forest Product Permits -** which are for a term of less than one year, provide volume-based rights to harvest specified forest products.

The Saskatchewan Ministry of Environment's Forest Service Branch, the forest industry and Saskatchewan residents are involved in various levels of forestry planning, including:

- Integrated Land Use Planning on Crown lands. The purpose of the Integrated Land Use Planning on Crown lands processes is to identify and integrate existing land use interests (including environmental, economic, social, and cultural uses), resolve conflict, and develop, through extensive consultation with stakeholders, land and resource management plans for Crown lands in the planning area. At present, the Saskatchewan Ministry of Environment is involved in six Integrated Forest Land Use Plans.
- Forest Management Plans (FMPs). FMPs are prepared to provide strategic-level direction for the management of forest resources in a forest management area. FMPs are twenty-year plans, renewable every ten years. To assess how well forest companies with FMAs have met the objectives set out in their FMPs, periodic Independent Sustainable Forest Management Audits are conducted. (Saskatchewan Environment 2003a).
- Operating Plans. The purpose of operating plans is to define operational intentions. Operating plans are to conform to Forest Management Plans where they are in place. Operating plans are prepared every year, but have a five-year planning horizon.

In the spring of 2009, the Government of Saskatchewan announced that it was adopting a results-based model for environmental regulation. This model will promote innovative tools in environmental management to improve environmental protection.

"In developing and implementing this results-based regulatory model, the Ministry of Environment will move forward on a number of initiatives, including:

- streamlining, consolidating and modernizing environmental legislation, starting with *The Environmental Management and Protection Act*, *The Environmental Assessment Act* and *The Forest Resources Management Act*;
- developing a Saskatchewan Environmental Code that will set the framework for improved environmental management through clear statements of desired environmental outcomes and standards;
- reorganizing the ministry to better deliver the requirements of results-based regulation;
- providing an electronic platform for environmental information and program delivery, including web-based environmental applications and reporting. This will mean a streamlined application process and transparency in reporting results; and
- continuing to engage the public, First Nations and Métis and stakeholders in consultation as the design and implementation of the new regulatory framework move forward" (Government of Saskatchewan 2009a).

To ensure that the provincial government is accountable to the people of Saskatchewan, *The Forest Resources Management Act* requires that a *State of the Provincial Forests* report be prepared every ten years. The Saskatchewan Ministry of Environment's Forest Service Branch has completed two forestry reports, building up to the *State of the Provincial Forests Report* to be released in 2010. The first *Report on Saskatchewan's Provincial Forests* was released in 2007 and provided background information about forestry in Saskatchewan, as well as the proposed *State of the Provincial Forests* indicator framework. The second *Report on Saskatchewan's Provincial Forests* was released in late 2008 and provided information on 11 indicators of sustainable forest management. The *State of the Provincial Forests Report* will be released in 2010 and will provide information on the health of Saskatchewan's provincial forests as assessed using 23 indicators.

To reduce the negative effects of harvesting and improve the likelihood of successful regeneration, forestry companies in Saskatchewan are now implementing harvest practices that emulate natural forest patterns. The Saskatchewan Ministry of Environment's Forest Service Branch began encouraging these new harvest practices beginning in 2004 (Saskatchewan Environment 2003b).

Industrial Influences

Contaminated Sites Indicator

This indicator reports on the environmental risk of contaminated sites at a watershed level. The Contaminated Sites Indicator is calculated as a combination of the number of contaminated sites in a watershed multiplied by a site classification category as defined by the Canadian Council of Ministers of the Environment's National Classification System for Contaminated Sites.

Indicator	
Contaminated Sites	**Status:** The Federal Contaminated Sites Inventory database contains 1,141 federal contaminated sites found in 28 of the 29 watersheds in Saskatchewan. Currently, the contaminated sites information collected by the Saskatchewan Ministry of the Environment is not included in this indicator. **Trend:** Due to limitations in the Federal Contaminated Sites Inventory database, trends in this indicator cannot currently be determined.

The issue

Contaminated sites are locations that have been designated as such because they represent a potential risk to humans or the environment. This includes the presence of one or more substances that are: 1) present at concentrations greater than background (i.e. normally occurring) and have the potential for immediate or long-term adverse effects to human health or the environment; or 2) in excess of those specified in policies and regulations (Government of Canada's Contaminated Sites Management Working Group 1995). Some of the environmental concerns associated with contaminated sites include the potential for the contaminant(s) to leach to ground or surface waters and/or the uptake and bioaccumulation of the contaminant(s) by plants or animals.

Contaminated Sites Indicator in Saskatchewan

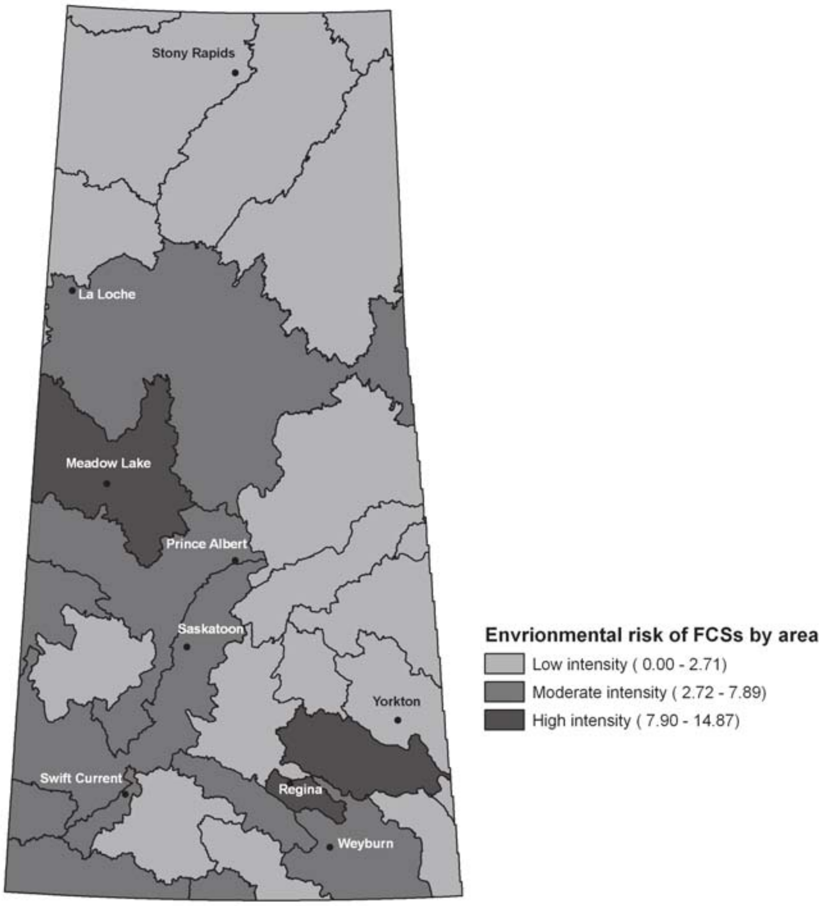

Figure 120. Environmental risk of federal contaminated sites, as listed on the Federal Contaminated Sites Inventory.

As of April 2009, there were 1,141 contaminated sites in Saskatchewan listed in the Federal Contaminated Sites Inventory that are either on federal land or on non-federal land for which the Government of Canada has accepted some or all financial responsibility. The contaminant type has been identified for 464 (41%) of the 1,141 contaminated sites. The identified contaminants include: petroleum hydrocarbons; polycyclic aromatic hydrocarbons; heavy metals; toxic organics; nuisance substances; benzene, toluene, ethylbenzene, and xylene; metals, metalloids and organometallics; PCBs (Polychlorinated Biphenyl) and PCDD/Fs (polychlorinated dibenzo-p-dioxin/dibenzofuran); pesticides; halogenated hydrocarbon; energetics; other inorganics; other organics; physical/chemical measures (pH, temperature, dissolved solids, turbidity, etc.); and others.

The watersheds with the highest intensity of environmental risk in regard to contaminated sites are the Beaver River, Lower Qu'Appelle River and Wascana Creek Watersheds.

Indicator		
Environmental Risk of Contaminated Sites	=	$\frac{\Sigma\text{ [Number of contaminated sites x Site classification category]}}{\text{Area of watershed (ha)}}$

Rating Scheme
Insufficient data from appropriate scientific studies existed to rate this indicator, so the Jenks' optimization method was used to identify the natural breaks in the data.

Environmental Risk of Contaminated Sites
Low intensity: Environmental stress of contaminated sites is less than 2.72.
Moderate intensity: Environmental stress of contaminated sites ranges from 2.72 and 7.89.
High intensity: Environmental stress of contaminated sites is greater than 7.89.

Data Source: Information on contaminated sites in Saskatchewan was obtained from the Federal Contaminated Sites Inventory (http://www.tbs-sct.gc.ca/fcsi-rscf/home-accueil.aspx?Language=EN&sid=wu5616365763) – accessed April 5, 2009.

Data Handling: For the contaminated sites obtained from the Federal Contaminated Sites Inventory, the environmental risk class is calculated using the Contaminated Site Classification Categories, where: Class 1 (Action required) = 4; Class 2 (Action likely required) = 3; Class 3 (Action may be required) = 2; and Class N (Action not likely required) = 1. If the Contaminated Site Classification Category is either undefined or Class I (insufficient information - the Contaminated Site Classification Category is currently unknown) the environmental risk = 2, as there is potential for action to be required.

Data Quality/Caveats: Currently trends in the number of contaminated sites over time cannot be determined, as the data used in this report comes from the Federal Contaminated Sites Inventory database, which does not indicate the date that the site became contaminated. Therefore, the increase in the number of contaminated sites from 157 sites in the 2007 *State of the Watershed Report* to 1,141 contaminates sites in this report is not an actual increase in the number of contaminated sites, but is instead due to when the data was entered into the database. The data used for the 2007 *State of the Watershed Report* was downloaded from the Federal Contaminated Sites Inventory Website before August 20, 2006, and at that point only 157 sites were entered into the database.

Data Discussion: The Saskatchewan Ministry of the Environment has approximately 8,000 records on contaminated sites in Saskatchewan that are not part of the Federal Contaminated Sites Inventory. Currently, the contaminated sites information for Saskatchewan is not in an electronic format. Data on spills in Saskatchewan are in an electronic format. Access to both of these data sources would improve the reporting of this indicator.

Response to the issue
The Saskatchewan Ministry of Environment regulates provincial contaminated sites through *The Environmental Management and Protection Act, 2002*.

Legislation has been developed to reduce the environmental impacts of contaminated sites and to ensure that the contaminated site is not abandoned. Federal legislation that applies to the management of contaminated sites includes the *Canadian Environmental Protection Act, 1999* and *Regulations*, the *Fisheries Act*, and the *Canadian Environmental Assessment Act*.

In addition to legislation, the Saskatchewan Ministry of Energy and Resources administers a number of guidelines related to spills, contaminated sites and waste disposal from upstream oil and gas operations. These include: the Spill Site Reclamation Guidelines; the Upstream Contaminated Sites Remediation Guidelines; the Environmental Site Assessment Guidelines; the Drilling Waste Management and Frac Fluid and Sand Disposal Guidelines; and the Interim Draft Industrial Landfilling Requirements for Wastes Generated from Upstream Oil and Gas Industry.

The Saskatchewan Ministry of Environment established the Provincial Enforcement Centre Spill Report Line to receive and record province-wide reports of spills and environmental emergencies. Provincial enforcement Centre staff can provide advice on reported spills and confirm if containment and cleanup measures are adequate.

In 1995, the Government of Canada established the Contaminated Sites Management Working Group to identify, assess, and manage federal contaminated sites. The Contaminated Sites Management Working Group is co-chaired by Environment Canada and the Department of National Defence and the Canadian Forces, and currently comprises 15 federal departments and agencies which cost-share the activities.

As of July 2000, the federal government, under the Treasury Board Federal Contaminated Sites and Solid Waste Landfills Inventory Policy, requires all custodian departments and agencies to establish and maintain a database of their contaminated sites. This information must be submitted at least once a year to the Treasury Board of Canada Secretariat for incorporation into the Federal Contaminated Sites inventory.

Each contaminated site in the Federal Contaminated Sites inventory has been or will be classified into one of five classes based on the national Classification System for Contaminated Sites (Canadian Council of Ministers of the Environment 1992).

Industrial Waste Indicator

The Industrial Waste Indicator was designed to identify the stress intensity of industrial waste at the watershed scale. Two ratings schemes are employed: one to assess the relative density of landfills among watersheds, and the other to assess the total tonnes of pollutants released and disposed by watershed.

Indicator	
Density of National Pollutant Release Inventory sites	**Status:** In the 2007 reporting year, 579 Saskatchewan facilities submitted substance reports to the federally-run National Pollutant Release Inventory (NPRI). In 2003, 472 facilities in Saskatchewan submitted substance reports to the NPRI. **Trend:** The density of NPRI sites increased significantly between 2003 and 2007.
Tonnes of pollutants released and disposed of by watershed	**Status:** In 2007, the release of 63 pollutants in Saskatchewan was reported to NPRI. In 2003, the release of 73 pollutants was reported to the NPRI. **Trend:** The total tonnes of pollutants released and disposed of in 2007 was 14% less than the tonnes of pollutants released and disposed of in 2003.

The issue

Industrial waste discharge constitutes a variety of substances, both organic and inorganic, including nutrients and toxins that can alter the structure and function of aquatic and terrestrial ecosystems. Air pollutant emissions contribute to smog, acid rain and poor air quality. Industrial and commercial waste is defined as any substance discharged, emitted, or disposed into the environment that originates through industrial or commercial manufacturing or chemical processing.

Industrial Waste Indicator in Saskatchewan

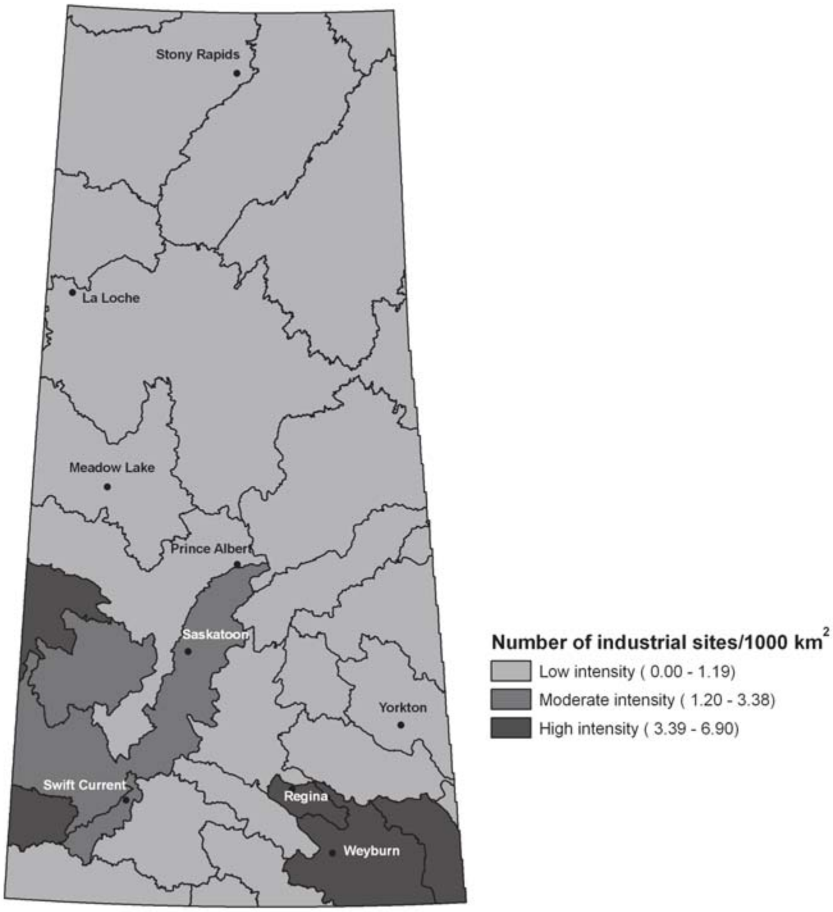

Figure 121. Density of industrial waste sites by watershed, as reported to the National Pollutant Release Inventory in 2007.

For 2007, the density of facilities that were legally required to report to the NPRI in Saskatchewan is rated as low intensity for 20 watersheds, moderate for four watersheds and high for five watersheds. The density of industrial waste sites in 2007 was highest in the Battle River, Cypress Hills North Slope, Lower Souris River, Upper Souris River and Wascana Creek Watersheds.

In the 2007 reporting year, 579 Saskatchewan facilities submitted substance reports to the federally-run NPRI. In 2003, 472 facilities in Saskatchewan submitted substance reports to the NPRI. A total of 317 of the facilities that reported in 2007 also reported in 2003.

Of the 579 facilities that reported to the NPRI in 2007, 69% were involved in mining and/or oil and gas extraction, 12% were involved in manufacturing, 9% were involved in transportation and warehousing, 4% were agricultural industries, 3% were utilities, and the remaining 3% were involved in retail trade, wholesale trade, educational services, and public administration.

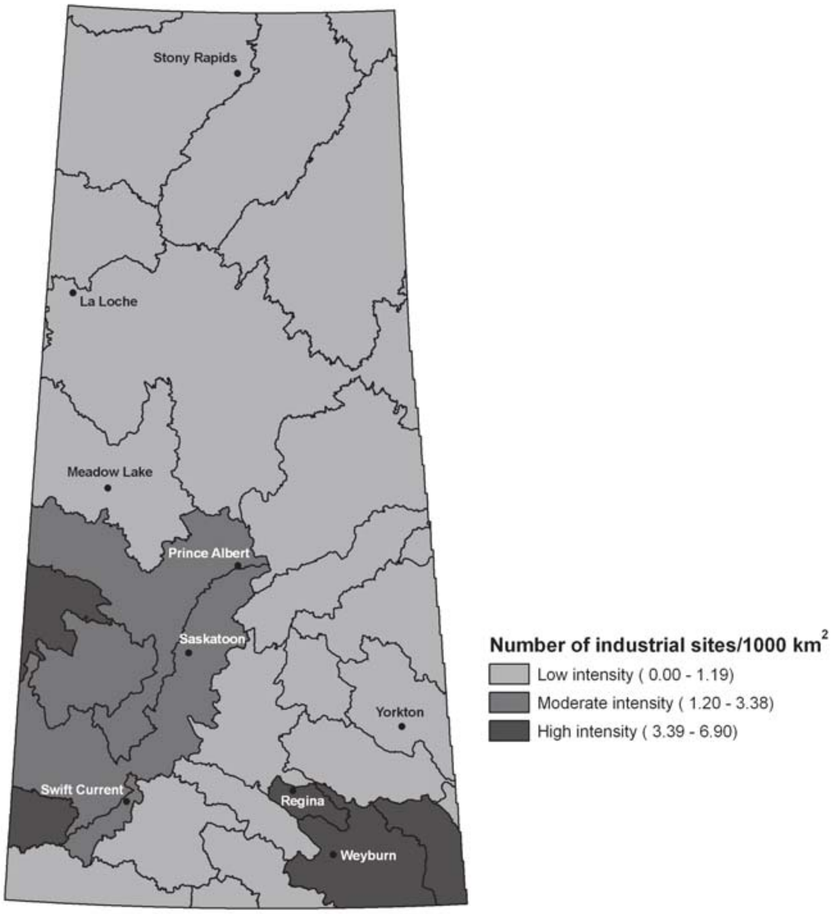

Figure 122. Density of industrial waste sites by watershed, as reported to the National Pollutant Release Inventory in 2003.

For 2003, the density of facilities that were legally required to report to the NPRI in Saskatchewan is rated as low intensity for 21 watersheds, moderate for three watersheds and high for five watersheds. The density of industrial waste sites in 2003 was highest in the Battle River, Cypress Hills North Slope, Lower Souris River, Upper Souris River and Wascana Creek Watersheds.

All Saskatchewan watersheds, with the exception of the North Saskatchewan River Watershed, had the same rating in 2007 as they did in 2003. In 2007, the number of facilities reporting in the North Saskatchewan River Watershed increased from 41 to 45, which increased the watershed's rating from low to moderate.

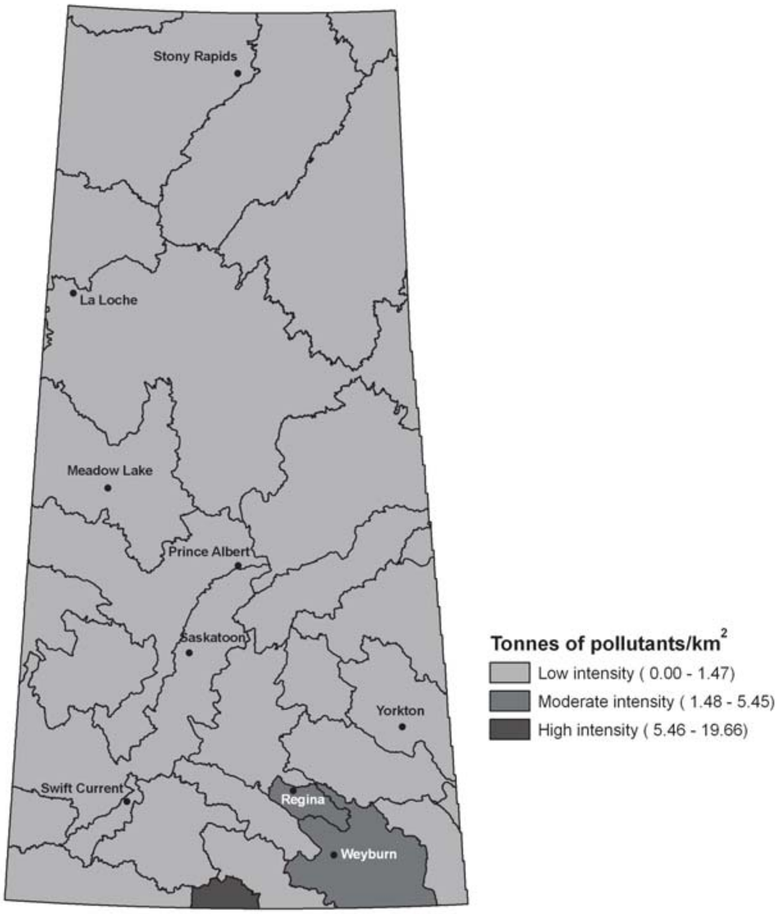

Figure 123. Tonnes of pollutants released and disposed of by watershed, as reported to the National Pollutant Release Inventory in 2007.

For 2007, the watershed intensity ratings for tonnes of pollutants released and disposed is low for 26 watersheds, moderate for the Upper Souris River and Wascana Creek Watersheds, and high for the Poplar River Watershed.

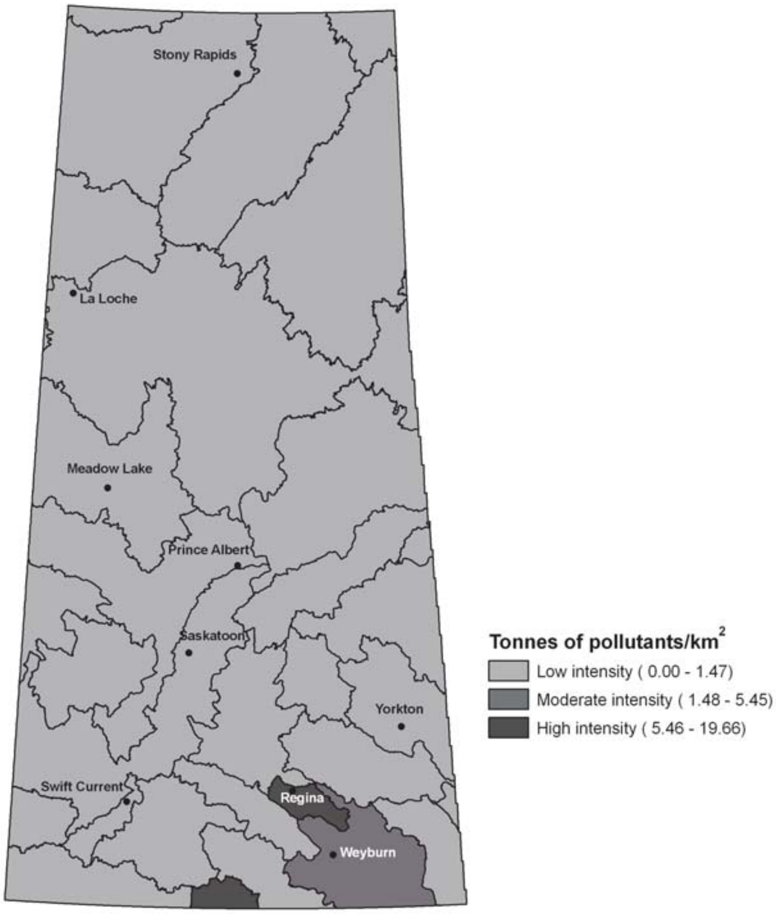

Figure 124. Tonnes of pollutants released and disposed of by watershed, as reported to the National Pollutant Release Inventory in 2003.

For 2003, 26 watersheds are classified as low intensity, the Upper Souris River Watershed are classified as moderate intensity, and the Poplar River and Wascana Creek Watersheds are classified as high intensity. The amount of pollutants disposed of and released in the Poplar River and Wascana Creek Watersheds were 18.69 and 18.79 tonnes/km^2, respectively. The amount of pollutants disposed of and released in the Wascana Creek Watershed decreased by 82% for the 2007 reporting year, compared to 2003.

Industrial point source discharge of waste to waterways poses a direct threat to source water in Saskatchewan. In 2007, in addition to nitrate and total phosphorus, industrial effluent from Saskatchewan facilities who reported to the NPRI also consisted of a mixture of 60 other chemicals. In 2007, 99% of the reported weight of pollutants disposed of and released are from the same chemicals reported on in the 2003 inventory.

Indicator		
Density of National Pollutant Release Inventory Sites	=	Number of facilities that reported the release or disposal of pollutants to the National Pollutant Release Inventory / Total area of watershed (km²)
Tonnes of Pollutants Released and Disposed of by Watershed	=	Tonnes of pollutants released and disposed of by watershed from National Pollutant Release Inventory facilities / Total area of watershed (km²)

Rating Scheme
Insufficient data from appropriate scientific studies existed to rate this indicator, so the Jenks' optimization method was used to identify the natural breaks in the data.

Density of National Pollutant Release Inventory Sites
Low intensity: Density of industrial waste sites is less than 1.20/1,000 km².
Moderate intensity: Density of industrial waste sites is 1.20 to 3.38/1,000 km².
High intensity: Density of industrial waste sites is greater than 3.38/1,000 km².

Tonnes of pollutants released and disposed of by watershed
Low intensity: pollutants released and disposed of are less than 1.48 tonnes/km^2.
Moderate intensity: pollutants released and disposed of are between 1.48 and 5.45 tonnes/km^2.
High intensity: pollutants released and disposed of are greater than 5.45 tonnes/km^2.

Data Source: Industrial waste site locations and tonnes of pollutants released and disposed of were obtained from the 2003 and 2007 National Pollutant Release Inventory (NPRI) database.

Data Quality/Caveats: This indicator includes only data on waste that was generated within Saskatchewan.

Data Discussion: Data are collected by the National Pollutant Release Inventory annually. However, it takes approximately a year after the data are reported for data quality checks to be completed.

Response to the issue
The Saskatchewan Ministry of Environment regulates industrial waste in Saskatchewan through *The Clean Air Act* and Regulations, *The Environmental Management and Protection Act, 2002*, and *The Water Regulations, 2002*.

The waste generated from the upstream oil and gas industry is regulated by the Saskatchewan Ministry of Environment through the Waste Management Guidelines for the Saskatchewan Upstream Oil and Gas Industry.

The Potash Refining Air Emissions Regulations, administered by the Saskatchewan Ministry of Environment, control air emissions from potash refineries. The regulations control the size of particulate matter released. They mandate that every owner of a potash refinery must, annually, conduct an emission test in relation to the potash refinery; and provide information on how to report an uncontrolled or accidental discharge of particulate matter.

The Abrasive (Sand) Blasting Guidelines, administered by the Saskatchewan Ministry of Environment, are guidelines which should reduce or eliminate any environmental risk associated with abrasive (sand) blasting. The guidelines include information on operating requirements and how to handle hazardous waste when encountered.

To address contaminants or issues that pose national concern, the federal, provincial (except for Quebec) and territorial Ministers of Environment have agreed to work together under the Canada-Wide Environmental Standards Sub-Agreement, to develop Canada-wide standards. Currently, the following Canada-wide standards have been developed:

- Canada-wide Standards for Mercury for Saskatchewan;
- Canada-wide Standards for Dioxins and Furans for Saskatchewan;
- Canada-wide Standards for Particulate Matter and Ozone for Saskatchewan;
- Canada-wide Standards for Benzene for Saskatchewan; and
- Canada-wide Standards for Petroleum Hydrocarbons for Saskatchewan.

Where applicable, the Saskatchewan Ministry of Environment enforces these standards by incorporating them into the operating permit of the relevant facilities.

In 1992, to regulate the release of industrial pollutants, Environment Canada established the National Pollutant Release Inventory (NPRI), Canada's legislated, publicly-accessible inventory of pollutant releases (to air, water and land), disposals and transfers for recycling. The purpose of the NPRI is to monitor the releases and transfers of pollutants from industrial sectors. It collects information on the releases, disposal and transfers of air, water, and soil pollutants from non-industrial and industrial sectors that meet the NPRI's established reporting criteria.

Industrial sectors that report to the NPRI include crude petroleum and natural gas, chemical and chemical products, paper and allied products, utilities, and metal mining. The NPRI annually develops a guide to be used by facilities to help determine if they need to report to the NPRI.

The NPRI does not collect information on pollutants from:

- mobile sources such as vehicles;
- certain sector activities such as agriculture, education, and some mining activities; or
- facilities that release pollutants on a smaller scale (NPRI 2009).

Environment Canada has compiled air pollutant emissions summaries of criteria air contaminants and selected heavy metals and persistent organic pollutants at a national, provincial, and territorial level. These emissions summaries and updated historical trends covering the 1985 to 2006 time period can be viewed online or downloaded in Excel format from the following website: http://www.ec.gc.ca/inrp-npri/default.asp?lang=en&n=F2B66EB1-1#n2.

In 2005, the Southeast Saskatchewan Airshed Association (SESAA) was established. The SESAA is comprised of representatives from government, industry, and stakeholders with a mandate to collect and publically disseminate credible, scientifically-defensible air quality data for the southeast region of Saskatchewan. Currently, SESAA monitors sulphur dioxide, nitrogen dioxide, hydrogen sulphide and ozone levels in the ambient air (Southeast Saskatchewan Airshed Association 2009).

SaskEnergy promotes energy efficiency by providing: rebate programs, such as The Saskatchewan EnerGuide for Houses Program and the Energy Efficient Rebate for New Homes Program; EnergyCheck, an on-line do-it-yourself home energy audit; and on-line energy saving tips (http://www.saskenergy.com/saving_energy). Reducing residential energy consumption reduces industrial emissions produced by coal-generated electricity plants and upstream oil and gas activities.

In Saskatchewan, some of the projects/activities that have been initiated to reduce industrial waste include:

- In 1998, PanCanadian Petroleum's Weyburn Carbon Dioxide (CO_2) Injection Project was initiated. The project pumps US-produced CO_2 into a Canadian oil reservoir. This project serves two purposes: it increases oil recovery and the lifespan of the oil field by 25 years, and also provides carbon dioxide storage. Within the duration of this project, it is estimated that there will be a reduction of 15.5 million tonnes of net CO_2 emissions from the North Dakota coal plant, which is thought to be equivalent to removing 3.2 million cars from the road for one year (Schempf 2001).
- In 1999, the International Test Centre for carbon dioxide capture was opened at the University of Regina. The Centre is developing carbon dioxide capture and storage technologies to reduce greenhouse gas emissions.
- In 2000, the International Energy Agency (IEA) Weyburn CO_2 Monitoring Project was initiated. This project is a monitoring project designed to study the results of storing CO_2 in an oil reservoir.
- In 2000, the Boundary Dam Pilot Plant was refurbished for the testing and demonstration of various CO_2 capture technologies, including proprietary CO_2 solvent extraction technologies. This process captures up to four tonnes of CO_2 per day (Wilson et al. 2004).
- In 2002, SaskPower introduced the Cypress Wind Power Facility located near Gull Lake, Saskatchewan. The facility has 16 wind turbines that produce 11 megawatts of electricity. These wind turbines produce electricity without generating greenhouse gases.
- In 2008, the Saskatchewan Ministry of Energy and Resources, in cooperation with the oil and gas industry, introduced the Saskatchewan Oil and Gas Industry Upstream Emission Reduction Initiative. This initiative focuses on opportunities to reduce emissions in the upstream oil and gas sector.

- On May 7, 2009, a Memorandum of Understanding (MOU) was signed between the Government of Saskatchewan and the State of Montana to initiate the Saskatchewan-Montana Project. The Saskatchewan-Montana Project will build a capture unit attached to an existing coal-fired power plant in Saskatchewan that will collect 300–1000 tonnes of CO_2 per day. The capture unit will consist of a pipeline that will deliver CO_2 from the Saskatchewan plant to a geological storage site in northeastern Montana (Office of Energy and Environment at the University of Regina's Website 2009).
- To encourage industry to reduce the emissions of greenhouse gases in Saskatchewan, the Saskatchewan Ministry of Environment introduced Bill No.95, The Management and Reduction of Greenhouse Gases and Adaptation to Climate Change, to the Saskatchewan Legislature on May 11, 2009. This Bill was passed and is now *The Management and Reduction of Greenhouse Gases Act.*