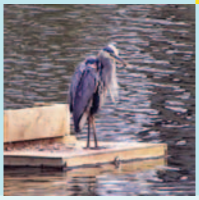
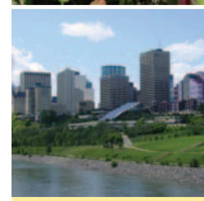


Chapter 4.0
Methodology



4.0 METHODOLOGY

4.1 INDICATORS BACKGROUND

Indicators and their metrics have become a useful regulatory tool and there is considerable information on the use of indicators. Indicators can be region-specific, system-specific or seasonal. For example, stream metrics are useful indicators for flowing water but not for detection of habitat changes in wetlands. The large geographical scale of this project also presents a challenge. Indicators must be useful throughout the watershed, or have a significant relevance to a portion of the watershed (e.g. *E. coli* in areas of higher human or livestock populations). Where possible, measures had to apply to the sub-watershed level to assist in future management decisions, which will be made at the local level.

The selection of indicators is not an exact science. There are several indicators and metrics that can be used for any given analysis. Our selection of indicators is based on an expectation that they will be useful in the next stage of the project – an integrated watershed management plan and because they are expected to indicate potential management issues that should be addressed in the integrated watershed management plan. For example, water quality and riparian health are measures that can be affected by land use changes or changes in land management practices.

4.2 INDICATOR DEVELOPMENT

NSWA's partner experts from government, industry, and non-government organizations met in Edmonton in May 2002 to determine a suite of indicators for use in the current state of the watershed report. The one-day workshop resulted in a master list of many indicators and several metrics for each indicator. As well, data sources for both the indicators and the metrics were identified for further information gathering purposes. As the master list of indicators was compiled, it became obvious that the selected indicators fell into one of four broad categories — land use, water quality, water quantity, or biological indicators.

4.3 METRICS

The challenge of choosing metrics for use on a watershed scale is in selecting a parameter that is applicable or that appears throughout the watershed. For example, the headwaters of the North Saskatchewan River are found in the Montane Natural Region in Banff National Park, and the river flows over several ecotypes before its departure into Saskatchewan in the Dry Mixedwood Natural Region. Ideally, the selected indicator would occur in all regions from the headwaters downstream. The 15 indicators in Table 1 and their respective metrics were chosen, based on the recommendations by the workshop group.

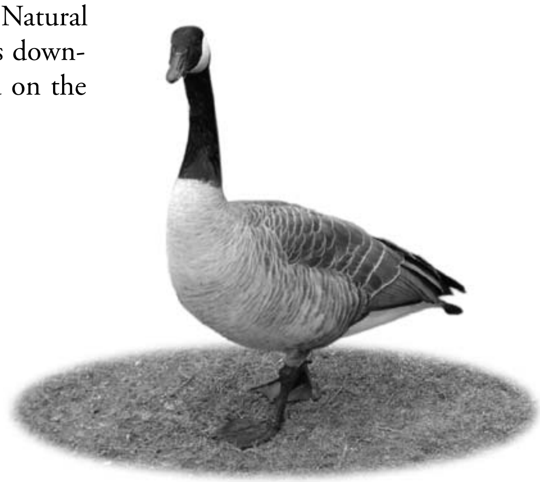






Table 1 : Metrics Chosen for Report.

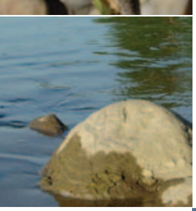
Indicator Category	Metric
Land Use	Riparian health
	Linear development (roads, seismic, pipelines, etc.)
	Land use inventory
	Livestock density
	Wetland inventory
Water Quality	Surface water quality index (AENV model)
	E. coli
	Phosphorus (TP, SRP)
	Pesticides
Biological Indicator	Aquatic macrophytes
	Fish (population estimates)
	Vegetation types (Alberta Vegetation Inventory)
	Benthic invertebrates

Several other key pieces of data are included in this report in addition to the selected indicators. These data provided background and contextual information that augment the other measures. They are:

- stream flows and discharges
- surface water and groundwater use
- effluent point sources and inputs
- population distribution
- land classification
- protected areas
- fertilizer and pesticide sales
- description of biota

With the above as a guide, the data were collected based on the indicators and metrics listed above.

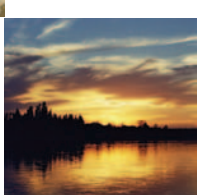




4.4 INDICATOR DETAILS

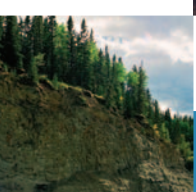
4.4.1 Land Use Metrics

Changes in land use patterns reflect major development trends such as forested lands converted to agriculture and agricultural lands developed and lost to urban development. Land use changes and the subsequent changes in land use practices will impact both the quantity and quality of waters in the North Saskatchewan Watershed. Five metrics are used to indicate changes in land use and land use practices: riparian health, linear development, land use, livestock density, and wetland inventory.



4.4.1.1 Riparian Health Inventory

Riparian areas are the important transition zone between uplands and surface water bodies. These areas perform several critical watershed functions and benefits such as trapping sediments and







filtering nutrients and pollutants, providing fish and wildlife habitat, aiding in erosion control, forage and hay production, improving water quality, and storage and slow release of water. Riparian areas in Alberta only make up 4% of the province's total area, but approximately 80% of fish and wildlife species depend on riparian areas for reproduction, food and cover (ARHMP Cows and Fish 1999). One of the best examples of comprehensive riparian work in the North Saskatchewan Watershed is the Vincent Lake Working Model. The Vincent Lake Working Model is a story of riparian health education, awareness and action. The details of the work completed by this group can be found in the Frog Subwatershed overview and online at www.healthyshorelines.com

A riparian health index has been developed by the Alberta-based Cows and Fish Program (www.cowsandfish.org) to examine vegetation, soil parameters, and hydrology of an area to reflect the adequacy of land use practices (Table 2). The health of the riparian area around water bodies and along rivers and streams is an indicator of the overall health of a watershed and the impact of changes in land use and management practices. The Cows and Fish inventory is based on an American model. It can be used by riparian resource management professionals to capture benchmark data, examine details of the plant community and structure, and for monitoring purposes. It is an important tool for examining the health of riparian areas, collecting baseline information, and for evaluating the impact of management changes over time.

Riparian health assessments are a rapid survey of an area and a quick calculation of relative health that compares a site's current condition to its potential. Health assessments can be undertaken for streams and small rivers, large rivers and lakes, and wetlands. While the inventory does not address water quality specifically, sites that are significantly disturbed will have a higher probability of impacting the surrounding waterbody. The inventory arrives at an overall health category for a riparian area which is identified by a health score. The ratings are:

Table 2: Cows and Fish riparian health score categories and score ranges.

Health Category	Score Ranges	Description
Healthy	80-100%	Little to no impairment to riparian functions
Healthy, but with problems	60-79%	Some impairment to riparian functions due to management or natural causes
Unhealthy	<60%	Severe impairment to riparian functions due to management or natural causes

Cows and Fish have completed riparian health assessments on 1,085 sites in Alberta including sites in the North Saskatchewan River watershed. Of all the riparian areas assessed in Alberta, 18% were considered "healthy," 52% were considered "healthy but at risk," and 30% were considered "unhealthy." Cows and Fish conduct riparian health assessments at the request of a community, watershed organization or individual and these sites are not randomly chosen. In the North Saskatchewan Watershed, assessments have been made across a diversity of sites, in terms of both health and system type. Sites were selected based on a combination of representative sampling (air photo stratification of habitat types) and interest-based sampling (landowners who request an inventory on their land). Some assessments may skew their representation from interest-based sampling, but in general the work in the North Saskatchewan Watershed has been a fairly even between the 2 sampling methods.

4.4.1.2 Linear Development

Recently, landscape ecologists have been studying the impacts from linear developments such as seismic activity, and





oil and forestry roads. For example, similar amounts of timber are removed in Alberta from seismic operations as is removed by the entire forest industry (Schneider 2002). From 1979 to 1995 an average of 57,750 km/year of seismic lines were approved in the Green Zone of Alberta (Alberta Centre for Boreal Studies 2001). As of 1999, the total length of seismic lines cut in the Green Zone was 1.5 million km (Alberta Environmental Protection 1998). However, unlike the forest industry, seismic operators are not required to reforest the lines that they cut and regeneration is slow (MacFarlane 1999, Revel et al. 1984). Because of inadequate regeneration, seismic activities result in a progressive loss of mature forest and alteration of forest structure. In subwatersheds with high rates of seismic activity, the cumulative loss of habitat may be substantial (Schneider 2002).

Quantifying linear development will help us understand potential changes in water quality and fish and wildlife populations that might result from resource extraction practices. For example, wildlife corridors can be altered by roads and watersheds can have their drainage patterns and water quality altered by increases in compacted surfaces.

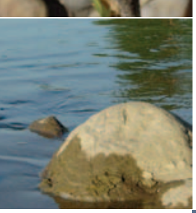
4.4.1.3 Land Use Inventory

A land use inventory quantifies natural landscape types, natural processes and land use practices. Quantification of land use types will allow us to calculate development in the watershed (timber extraction, oil lease lands, and natural disturbances such as forest fires). In addition, areas of undisturbed lands are quantified (such as wetland, river, lake and park areas). The land use inventory may be linked to land use changes and used to explore changes in water quality and quantity, fish and wildlife populations and riparian health.

4.4.1.4 Livestock Density / Manure Surrogate

A subcomponent of the agricultural sector's dynamics is the category of livestock density, which is typically expressed as the number of head of livestock per unit area. Areas of higher livestock density within a subwatershed can have greater impacts on downstream aquatic systems. Results from a recent study by Alberta Environment show that streams that drain land farmed with high intensity have higher nutrient concentrations, dissolved nutrients, mass loads, fecal bacteria and total dissolved phosphorus than streams that drain land farmed at medium or low intensity (Anderson et al. 1998). Alberta Agriculture, Food and Rural Development studies have shown that surface water in watersheds with high agricultural activities are more susceptible to enrichment from phosphorus and contamination from pesticides and fecal coliforms (CAESA 1998).

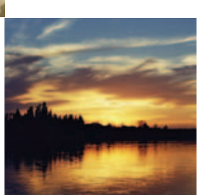
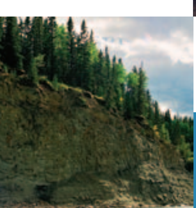




Manure production on Provincial soil polygons (in tonnes) is used as a surrogate for livestock density (Figure 4). Manure production information was available from Statistics Canada's 1996 Census of Agriculture. The data were broken down for Alberta on the basis of existing Alberta soil polygons by PFRA (Hiley and Lindwall 1998). A limitation of this data is that the polygons used do not correspond exactly to sub-watershed boundaries and therefore provide only a rough estimate of manure production within the actual sub-watershed. Manure production within these soil polygons is presented in tonnes per soil polygon.

4.4.1.5 Wetland Inventory

A subcomponent of the land use inventory is an inventory of wetlands. Wetlands serve many functions in the natural landscape including water storage, flood attenuation, evaporation, wildlife habitat, groundwater recharge and general water quality improvement. The loss of wetlands and their function to agriculture and other development can have significant negative impacts on water quantity and quality. Several wetland inventory datasets exist and we present wetland GIS inventory data from Agriculture and Agri-Food Canada (PFRA), Alberta Sustainable Resource Development's hydrological features and inventory data from Ducks Unlimited Canada.

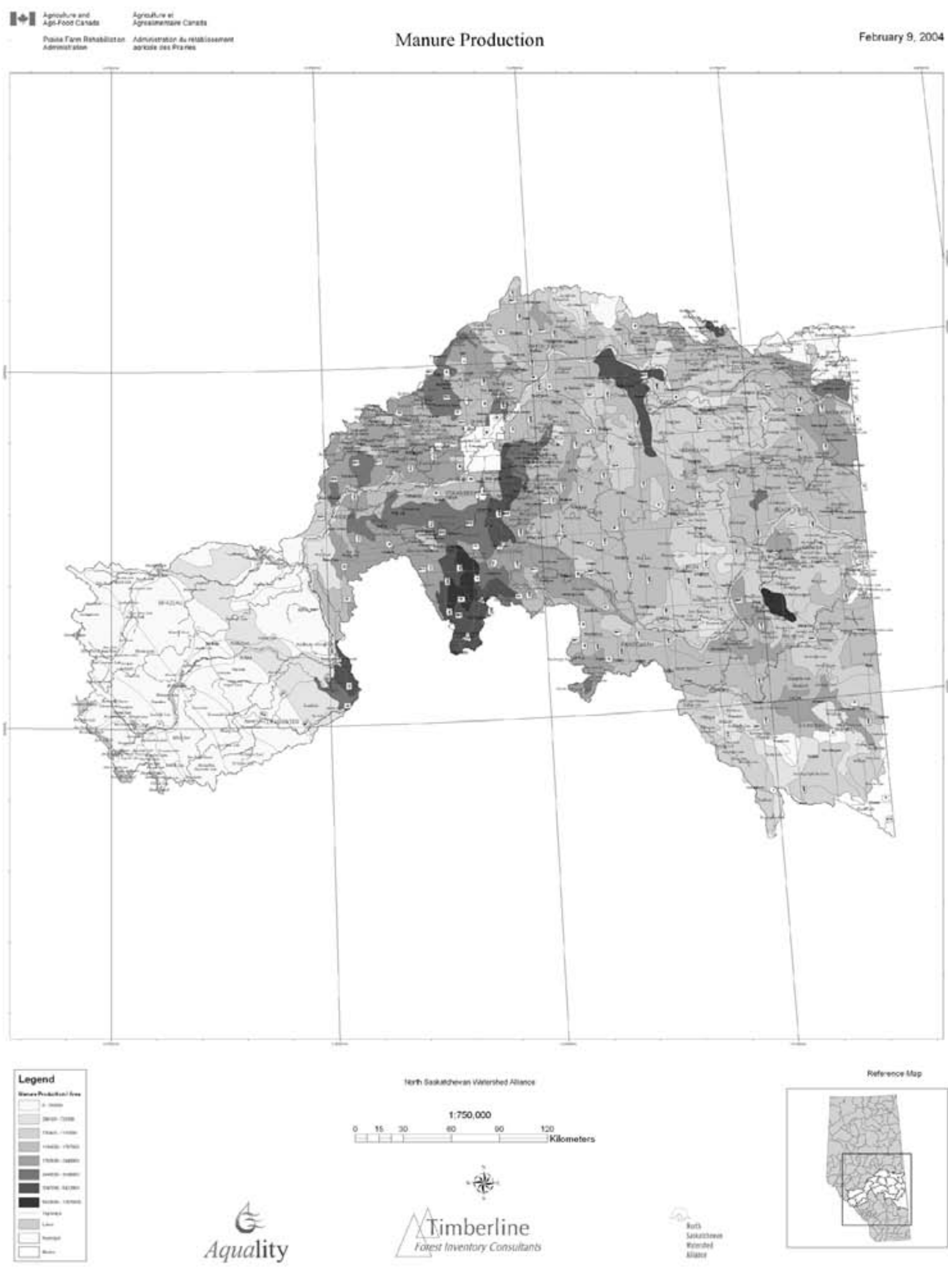
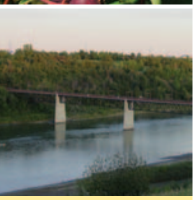


Figure 4: Manure production in the North Saskatchewan Watershed by soil polygon data.

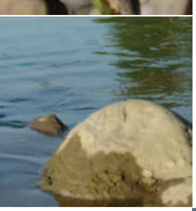
4.4.2 Water Quality Metrics



Water quality changes over time can indicate a change in the state of the watershed. Changes in water quality may be brought about by changes in land use or land management practices, landscape disturbance, and natural events. The following activities can significantly impact water quality: logging, mining, wetland drainage, dredging, dam construction, agricultural runoff, industrial and municipal effluents, land erosion, road construction and land development. Many other human activities and natural processes can impact surface and groundwater quality.

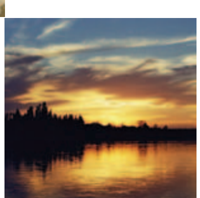
The North Saskatchewan River is monitored in Alberta at several sites. Whirlpool Point, the headwater site in Banff National Park, is monitored by Parks Canada and Environment Canada and a long-term dataset exists for this station (1972-present). Two other Environment Canada sites exist at Lea (Jubilee) Park (in Marsburg) and where the river crosses Highway 17, near the Alberta-Saskatchewan border. As the river flows through the City of Edmonton, water is treated and distributed by EPCOR Water Services to Edmonton and surrounding communities and wastewater is treated at City of Edmonton and Capital Region's treatment plants, and returned back the river. Stormwater from the City is also released back to the river, either directly or following treatment processes.

The North Saskatchewan River water quality is most intensely monitored around the City of Edmonton. The City of Edmonton, Alberta Environment, EPCOR Water Services and the Capital Region have an extensive Environmental Monitoring Program. This program was originally developed because the river is now used largely as the drinking water source and the wastewater recipient for the City of Edmonton and the greater Capital Region. Alberta Environment undertakes comprehensive water quality monitoring in the North Saskatchewan River at Long Term River Network (LTRN) stations at Devon and Pakan.

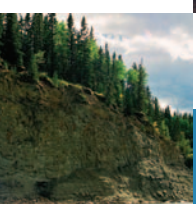


Several other agencies collect water quality data within the North Saskatchewan Watershed. These include Alberta Agriculture, Food and Rural Development under the Alberta Environmentally Sustainable Agriculture (AESA) program, Agriculture and Agri-Food Canada —Prairie Farm Rehabilitation Administration (PFRA), Riverwatch and the Alberta Lake Management Society (ALMS) under its Lakewatch program.

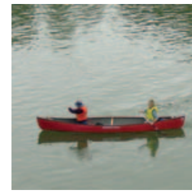
While AESA and PFRA water quality monitoring programs focus mainly on agricultural watersheds in Alberta, data will be presented where available within the North Saskatchewan Watershed. ALMS collects, analyzes and publishes its lake water quality data gathered under the Lakewatch program for several lakes in the watershed (www.alms.ca). Lakes with data available will be identified throughout this report. Although it was published in 1990, the Atlas of Alberta Lakes (Mitchell and Prepas 1990) contains information on 20 lakes within the North Saskatchewan Watershed and may be consulted for detailed background information and historic water quality data. Riverwatch monitors river water quality at three sites within the North Saskatchewan Watershed (www.riverwatch.ab.ca). These three sites include four stations along the river near the Town of Drayton Valley, and sixteen stations within the City of Edmonton. Finally, other water quality and quantity data collected by industry, volunteer watershed groups or consultants has not been considered in this report, but may be available and relevant to watershed groups.



Little data exists on groundwater sources and quality. However, Alberta Environment, Alberta Sustainable Resource Development, Agriculture and Agri-Food Canada, the Alberta Geological Survey or your local municipality should be contacted for any information on groundwater aquifers within the North Saskatchewan Watershed.



A full listing of watershed groups active in the North Saskatchewan Watershed and throughout




Alberta appears on . Where these volunteer watershed groups exist within a sub-watershed, they are identified. The following are water quality metrics that were chosen for this Report.

4.4.2.1 Alberta Surface Water Quality Index

The Alberta Surface Water Quality Index (Alberta Environmental Protection 1996) was developed to mathematically combine a number of variables into one easily understood rating system. The Index summarizes chemical, biological, and physical data into a simple composite descriptor of water quality. Results can be used to compare water quality conditions at multiple locations and over time at a particular location. The Index is not meant to replace the conventional scientific process of analyzing and interpreting water quality data, but does provide a simple “snap-shot” of yearly water quality conditions in various areas of the province.

The formula used for the Alberta Surface Water Quality Index was developed in parallel with the Federal CCME Water Quality Index (CCME 2001) and the mathematics behind both are identical. The index incorporates three factors representing key aspects of water quality: the number of variables not meeting objectives (scope); the number of times objectives are not met (frequency); and the amount by which objectives are not met (amplitude). The overall index value is based on the mean of four sub-indices that are calculated for metals, nutrients, bacteria, and pesticides or other combinations of water quality parameters that are ranked ‘Excellent’, ‘Good’, ‘Marginal’, ‘Fair’, or ‘Poor’.

The overall Alberta Surface Water Quality Index is based on the average of four sub-indices that are calculated for metals (up to 22 variables), nutrients (6 variables, including oxygen and pH), bacteria (2 variables), and pesticides (up to 17 variables). The objectives for the variables in the first three groups are drawn from guidelines listed in Surface Water Guidelines for Use in Alberta (Alberta Environment 1999). Variables in the fourth group (pesticides) are evaluated based on whether or not they can be detected in a water sample. The conservative approach for pesticides was adopted because some do not yet have official guidelines and, unlike metals, nutrients, and bacteria, pesticides do not occur naturally in the environment. This approach is valuable in assessing cumulative impacts of most land-use disturbances, and point and non-point source pollution throughout Alberta. Pollutants specific to a particular industry (i.e. arsenic and mining) can be included in the index to address the impacts of a specific industrial impact.

While Alberta Environment monitors surface water quality at many river and lake locations, only data collected as part of the province’s Long-term River Network (LTRN) are used for the Index. The Index values are calculated annually for each site based on monthly data collected between April of one year and March of the next. Many Index sites are selected to represent conditions upstream and downstream of major urban areas or other development. This is the case for the LTRN sites within the North Saskatchewan Watershed, with a site upstream of Edmonton at Devon, and a site downstream of Edmonton at Pakan.

The Alberta Surface Water Quality Index is included as a provincial performance indicator in the Alberta Government’s Annual Report, “Measuring Up,” published by the Ministry of Finance each June. The Index also appears in the Ministry of Environment’s “Annual Report” and “Business Plan”. Alberta Environment uses the Index to evaluate the goal of bringing water quality downstream of developed areas in line with upstream conditions, while maintaining or improving water quality at all sites over the long-term.





4.4.2.2 Escherichia coli *(E. coli)*

Escherichia coli is one of three bacteria commonly used to measure direct contamination of water by human or other mammalian wastes. These are a group of bacteria associated with the feces of warm-blooded animals. Waters that are polluted may contain several different disease-causing organisms, commonly called pathogens. Enteric pathogens, those that live in the human intestine, can carry or cause a number of infectious diseases. Contact or consumption by humans and other animals may result in gastroenteritis. Environmental quality guidelines exist for *E. coli* in drinking, agricultural and recreation water and for aesthetic purposes. Due to the short survival time of these organisms outside of an animal's body, the impacts of these pathogens can be short-lived or episodic following larger precipitation events.

4.4.2.3 Phosphorus Concentrations (Total and Soluble Reactive)

Phosphorus is a nutrient required for the growth and development of animals and plants. In aquatic systems, phosphorus typically is the limiting nutrient and, when added to aquatic systems, enriches productivity. Other changes, including increased macrophyte (large aquatic vegetation) growth, algal blooms, decreasing water clarity and fish kills, may result from excessive phosphorus inputs to aquatic systems. Environmental quality guidelines exist for phosphorus to protect water quality for aquatic life, recreation and livestock watering (CCME 1999). Phosphorus is an accepted nutrient surrogate and can be measured by Total Phosphorus (TP) and Soluble Reactive Phosphorus (SRP); an estimate of phosphate. Changes in phosphorus concentrations in aquatic systems can be linked to changes in land use, land use activities and management practices. Phosphorus concentrations are directly comparable between similar systems (i.e. lakes or rivers) and both snapshot and trend information are valuable.

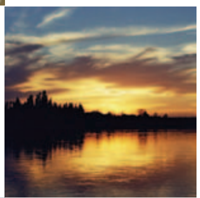
4.4.2.4 Pesticides



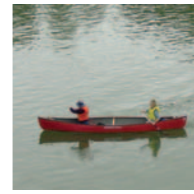
Peticides are a group of chemicals including herbicides, insecticides, rodenticides and fungicides. They are used for many purposes including pest control and aesthetics in urban areas, golf courses, and in forestry and agricultural production. Pesticides are a common contaminant of streams and dugouts in high intensity agricultural areas of Alberta (CAESA 1998). Herbicides were detected in 54 of 112 dugouts sampled in 1994 and 10 of 14 dugouts sampled in 1996 in Alberta (CAESA 1998). Pesticides can be linked to land use, land use activities and management practices.

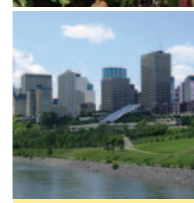
Herbicide, insecticide and fungicide production on Provincial soil polygons (in tonnes) were used as a surrogate for pesticide application (Figures 5a, 5b and 5c). Herbicide, insecticide and fungicide production information was available from Statistics Canada's 1996 Census of Agriculture. Like the manure data, these data were broken down for Alberta on the basis of existing Alberta soil polygons by PFRA (Hiley and Lindwall 1998). A limitation of this data is that the polygons used do not correspond exactly to sub-watershed boundaries and therefore provide only a rough estimate of manure production within the actual sub-watershed. Pesticide production within these soil polygons is presented in tonnes per soil polygon.

4.4.3 Water Quantity Metrics



Water quantity is important to maintain riparian health. Healthy riparian areas provide high quality aquatic habitat, have functions that are related to water quality, are essential for the treatment and production of drinking water, and are essential for the treatment of discharged wastewater (i.e. assimilation capacity). Irrigation, industry, recreation and livestock production all depend on a minimum amount of water. The minimum flow requirements of all users (including the needs of



the aquatic organisms) are expressed by studies on Instram Flow Needs (IFN), a new approach in aquatic science that is now being developed in Alberta. Water quantity is necessary for many recreational activities, and the public is quick to respond in the absence of expected quantities of water in the environment and for their personal use.

HYDEX is an inventory database of Environment Canada's streamflow, water level, and sediment stations (both active and discontinued) throughout Canada. The database contains station information including location, equipment, and type of data collected. is Environment Canada's database of computed data for HYDEX stations and includes data on daily and monthly means of flow, water levels and sediment concentrations (for sediment sites). For some sites, peaks and extremes also are recorded. The data are collected by regional offices **and** updated once each year. This update generally occurs in mid-summer for the previous year (e.g. summer 2004 for 2003 data). Each year, a new HYDAT is produced that updates the previous CD-ROM. Data from many stations is also available on Alberta Environment's website (http://www3.gov.ab.ca/env/water/GWSW/quantity/).

The North Saskatchewan River has been monitored at 128 flow gauging stations on the river, some since 1908 (Figure 6). Of the sixty-six currently active stations, 23 have real-time data available on the Environment Canada website (Environment Canada 2004a). HYDAT 2001 is the latest Water Survey of Canada flow dataset. This can be downloaded from the Environment Canada website (Environment Canada 2004b). Available HYDEX stations and HYDAT data will be identified for each sub-watershed in this report.
The following are water quantity metrics that were chosen for this Report.



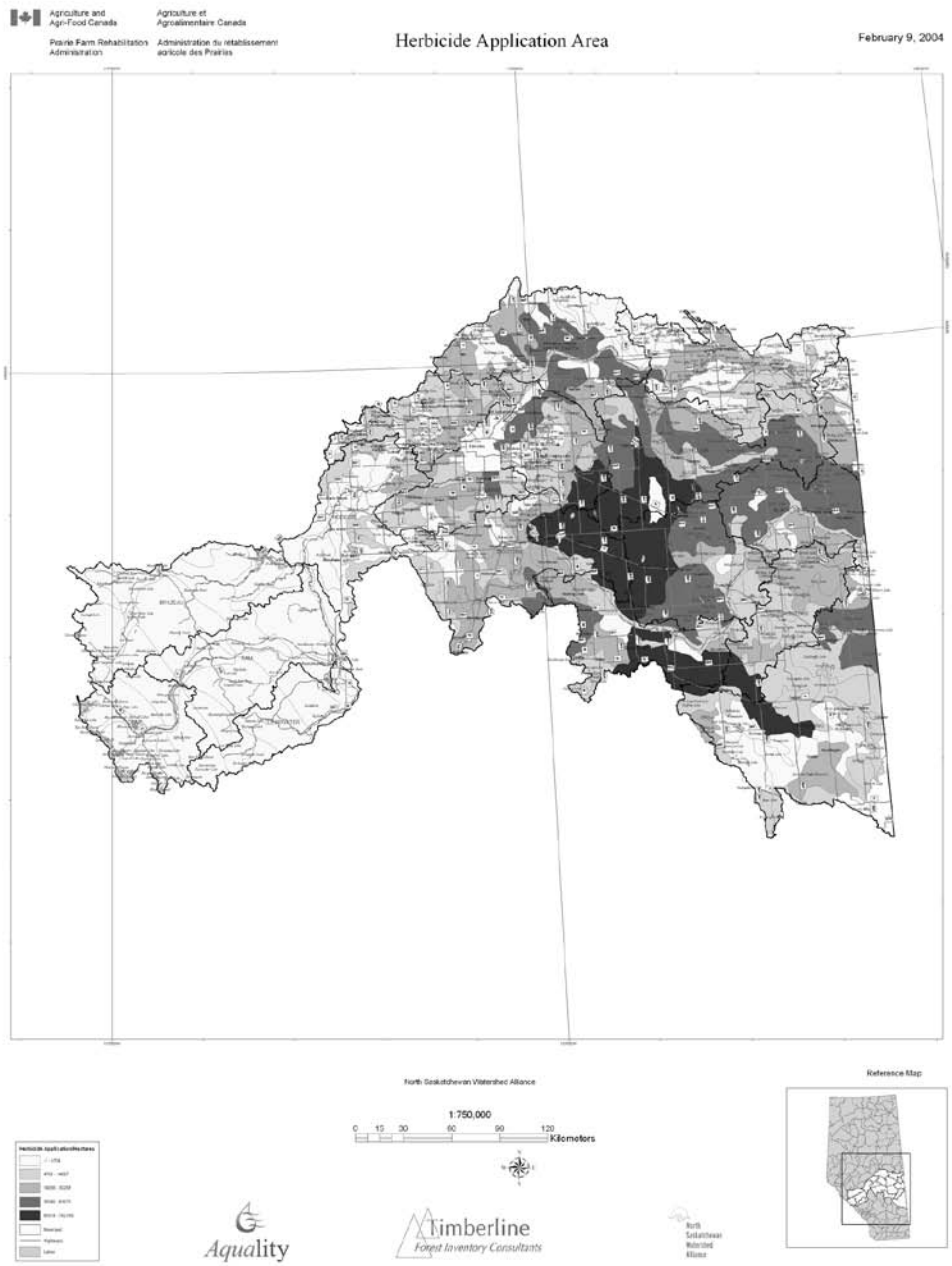



Figure 5a: Herbicide production in the North Saskatchewan Watershed by soil polygon data.

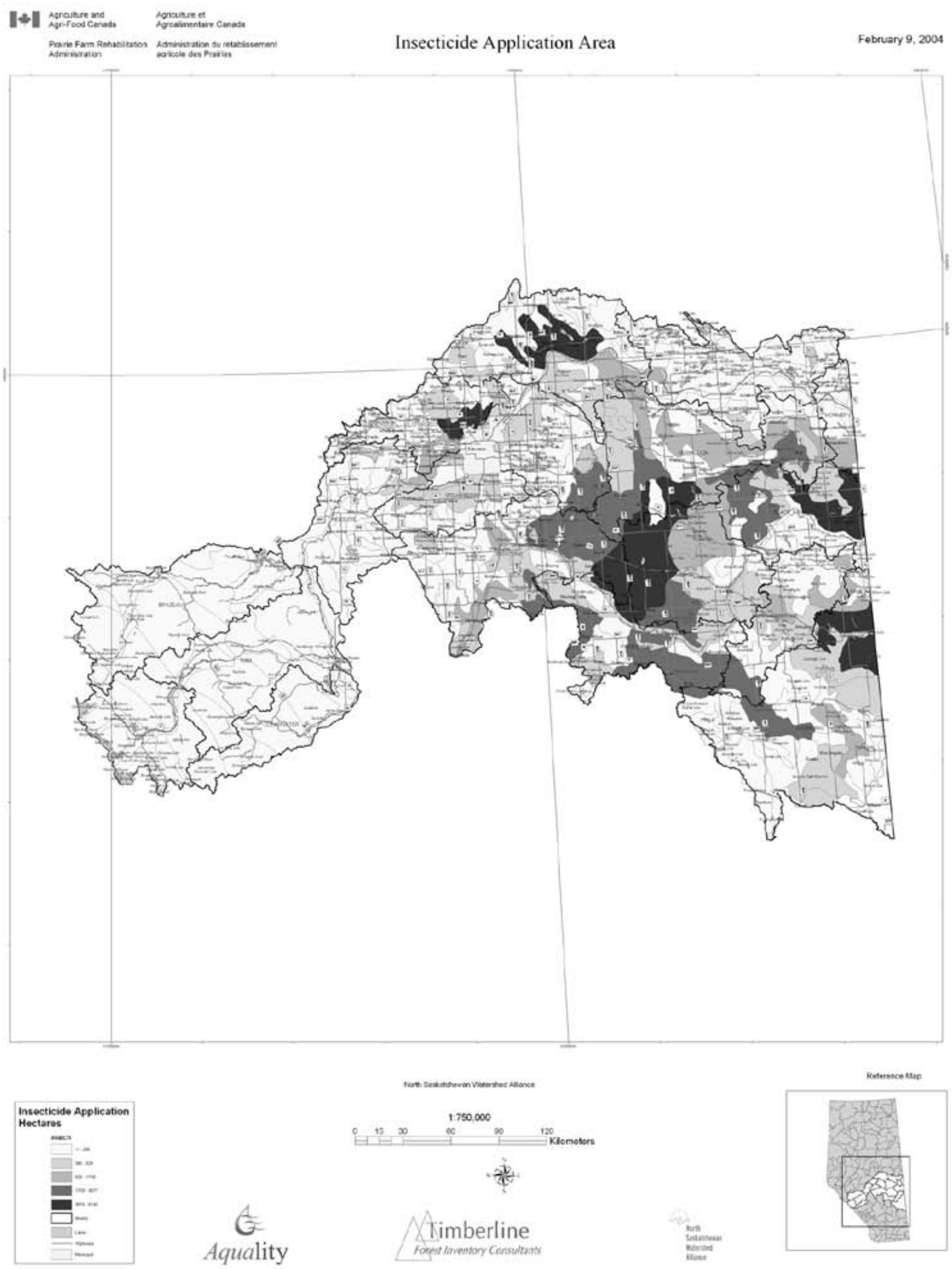


Figure 5b: Insecticide production in the North Saskatchewan Watershed by soil polygon data.

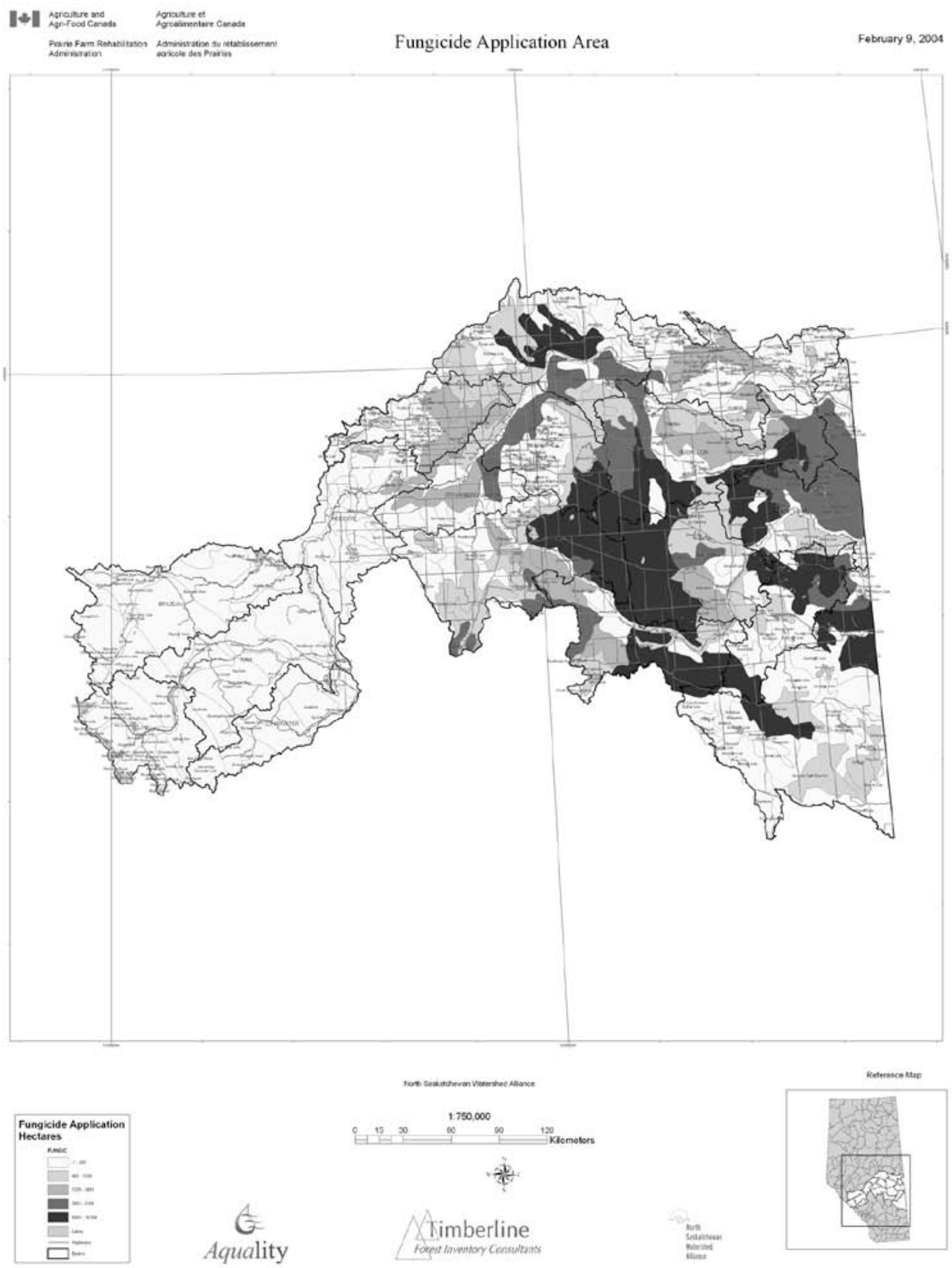


Figure 5c: Fungicide production in the North Saskatchewan Watershed by soil polygon data.





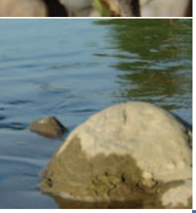
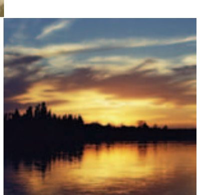
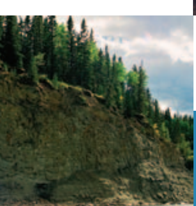



Figure 6: North Saskatchewan Watershed hydrometric (water flow gauging) stations. *Please see pocket or the pdf file on the CD ROM for map.*







4.4.3.1 Water Allocations by Sector

Surface water withdrawal permits for the watershed are identified by user sector (agriculture, municipal, industrial) along with information on licenses for the top ten users of surface water. This information is used along with water flow data to show areas of potential future constraints on surface water availability, which can have implications on development.

4.4.3.2 Groundwater Extraction

Groundwater withdrawal permits for the watershed are identified by user sector (agriculture, municipal, industrial) along with information on licenses for the top ten users of groundwater. This information may be used along with groundwater flow data to show areas of potential future constraints on groundwater availability, which could have implications for development.

4.4.4 Biological Indicator Metrics

Biological Indicators are biological (plant and animal) data from which various aspects of ecosystem health can be determined or inferred. The presence, absence and abundance of these organisms can be linked to water quality, quantity and ultimately to watershed health.

4.4.4.1 Aquatic Macrophytes

Aquatic macrophytes are large aquatic plants, which can be rooted, submersed, emergent or sessile. Their growth is directly related to the availability of phosphorus in aquatic systems. Excessive macrophyte growth or changes in species abundance and distribution may indicate decreased water quality, may have detrimental impacts on other aquatic organisms, and alter habitats and flow rates. Excessive growth may be linked to various point (wastewater outfalls) or non-point (general run-off) sources related to municipal development or land use practices.

4.4.4.2 Fish (Population Estimates)

Inventories of selected fish populations may show increases or decreases through introductions or changes in environmental conditions. The presence and abundance of fish species may also be related to changes enviromental factors such as water quality or quantity. Indicator species that are sensitive to environmental pollution may show areas of concern with their absence, while others may show similar with their presence.

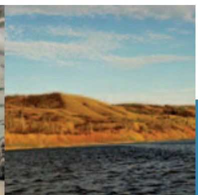
4.4.4.3 Vegetation Types

Inventories of flora populations may show increases or declines through introductions or changes in environmental conditions. Indicator species that are sensitive to environmental pollution may show areas of concern with their absence, while others may show areas of concern with their presence.

4.4.4.4 Benthic Invertebrates

Benthic or bottom dwelling invertebrates can be sensitive to environmental changes, and are an important food source for higher trophic levels. Several invertebrate species such as mayflies and caddisflies are excellent indi-





cators of aquatic health. Alberta Environment has developed a "key" to the identification of the most common taxa of freshwater invertebrates occurring in the major rivers of Alberta. The key was prepared to accompany project materials on the biological monitoring of water quality (Anderson et al. 1983)



4.5 ASSESSING WATERSHED HEALTH

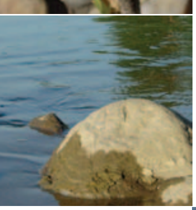
What constitutes a healthy watershed is a fundamental question that can be difficult to answer. A healthy watershed performs a number of functions that keep the ecosystem in balance, and when these functions are compromised, watershed health can be negatively affected. Resource and other types of human-influenced development need to be undertaken in ways that protect the ecological integrity of a watershed. If not, the functions we require of watersheds – primarily producing a safe and abundant water supply – become jeopardized. Watershed health will ultimately be determined by the users of watershed resources. While measuring "watershed health" is difficult, we can choose parameters as indicators that can represent elements of watershed health, such as water quality measures of nutrient concentrations. In this example, water quality is the indicator, and nutrient concentration is a specific measurement or "metric" of the water quality indicator.

Environmental indicators are general measures of environmental quality that can be used to show trends of environmental conditions. Their purpose is much like a performance measure, to show how well a system is functioning over time.

To be effective, and indicator must be:

- Relevant - able to show you something about the system that you need to know
- Straightforward
- Easy to understand
- Reliable - the information the indicator provides is trustworthy
- Timely - the information is available while there is still time to act



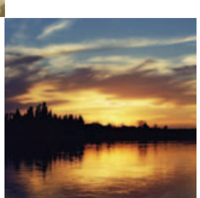


In addition, a good environmental indicator can simplify large amounts of complex information into a concise, easily understood format such as the Alberta Surface Water Quality Index (Alberta Environmental Protection 1996).

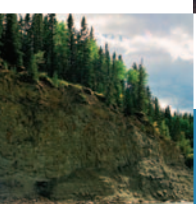
In order to report on watershed health, each indicator was examined individually, and determined if it was high or low, based on its occurrence across all 18 subwatersheds. The range of each metric (or measure of the indicator) was plotted and subjectively broken into a high, medium and low value for each. Where they exist, values from the scientific literature were used to assess their ability to impact the landscape, and thus watershed health. For example, the literature suggests that linear disturbance greater that 3% can significantly impact water quality. Based on the above assessment methods, the following rankings were used:

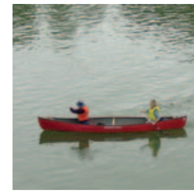
- Linear disturbance below 2% was considered good, between 2 and 3 percent was fair and above 3% was poor.

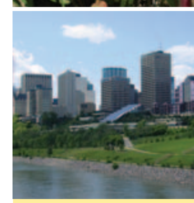
- Total phosphorus less than 100 ug/L was good, between 100 ug/L and 199 ug/L was fair and 200 ug/L was deemed poor.



- Livestock density that was low was deemed good, medium low and medium was deemed fair medium high and high was deemed poor.
- Land use disturbances of less than 50% disturbed lands were deemed good, between 50% and 89% fair, and greater than 90% poor.





- Riparian health rankings were already provided by Cows & Fish. The highest percentage ranking was used to rank the subwatershed. For example, in the Frog subwatershed there were more healthy riparian areas (46%) than any other ranking, therefore the watershed was deemed to have 'healthy' riparian areas.

- E. coli counts between 0 and 50 were deemed good, counts between 51 and 100 were deemed fair, and counts greater than 100 were deemed poor.

- Wetland coverage of greater than 10% in a subwatershed were deemed good, between 5% and 9% fair, and below 5% were deemed poor.

- Alberta Surface Water Quality Index ratings of good were deemed good, fair and marginal were fair, and poor were deemed poor.

- No systematic studies of aquatic macrophytes were done in any watershed. However, if studies found aquatic macrophytes, the overall health in the watershed was assumed to be 'fair'. This knowledge gap must be addressed before a more accurate assessment can be made.

- No systematic studies of benthic invertebrates were done in any reach of the watershed. However, if studies found benthic invertebrates, the overall health in the wateshed was assumed to be 'fair'. This knowledge gap must be addressed before a more accurate assessment can be made.

- No systematic studies of fish populations were done in any reach of the watershed. However, if studies found fish populations existed, the overall health in the wateshed was assumed to be 'fair'. This knowledge gap must be addressed before a more accurate assessment can be made.

4.6 DATA COLLECTION

Digital data were assembled from a variety of freely-available sources such as agency internet websites, and where possible, through data-sharing agreements with NSWA partners. The focus for data collection was the indicators selected by the expert panel that represented water quality, water quantity, land use and biological indicators. Data-sharing agreements were established with Alberta Sustainable Resource Development, Agriculture and Agri-Food Canada–PFRA and Ducks Unlimited Canada. Other sources of data are referred to throughout this report.

Digital datasets compiled for this project include:

- Alberta Agriculture, Food and Rural Development Soils Data (AgraSid 3.0)
- ASRD Native Vegetation Project
- ASRD Base Features Data (Land Use, Water Hydrology, Parks and Protected Areas)
- PFRA Landcover Polygons, Generalized Landcover and Hydrology Layers (including wetlands)
- Natural Resources Canada Data (Hydro, Rail, Ecozones, Ecoatlas, Climate Changes, Soils Water, Radarsat, Soils, Water, Canada Land Inventory data)
- Ducks Unlimited Canada Wetland Habitat Inventory - Landsat Based Inventory (30m)
- Statistics Canada 2001 Census of Agriculture (Manure Production, Cropland, Summer Fallow and Unimproved/Improved Pasture Data). This was the only dataset that had to be purchased by the NSWA.