CANADA-SASKATCHEWAN
SOUTH SASKATCHEWAN RIVER BASIN STUDY

TECHNICAL APPENDIX II

RESOURCE ASSESSMENT

D. ENVIRONMENT

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JULY, 1991

ACKNOWLEDGEMENTS

This technical appendix was assembled by the staff of the South Saskatchewan River Basin Study Office. It is based on information from the references cited in the document, the technical reports listed in Appendix A, and extensive consultation with private and government interest groups. The efforts of EMA Environmental Management Associates Ltd. in the preparation of this document are appreciated.

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1.0 INTRODUCTION

1.1 THE SOUTH SASKATCHEWAN RIVER BASIN STUDY

The results of the Canada-Saskatchewan South Saskatchewan River Basin Study (SSRBS) are documented in a series of reports. The final report provides a summary of the findings in a form suitable for use by the general public. The final report is supported by seven technical appendices: Issues Documentation, Water Quantity, Water Quality, Water Use, Environment, Water Management and The Framework Plan. The technical appendices provide sufficient detail for use by water management professionals. The technical appendices are based on detailed studies reported in more than 60 technical reports prepared for the basin study and various reports on the study area prepared for other purposes. A complete list of the technical reports is included in Appendix A of this report.

This technical appendix, "ENVIRONMENT", documents the status of the environmental resources of the South Saskatchewan River Basin in Saskatchewan and provides an assessment of the effects of water-related activities and developments on those environmental resources. The topics which are addressed include wildlife, endangered species, fisheries, heritage resources, wetlands, International Biological Program (IBP) sites and environmentally sensitive areas.

In order to provide some context for this report, sections have been included on the background to the study and on the water resources of the study area.

1.2 STUDY BACKGROUND

The South Saskatchewan River is the most reliable supply of good quality water in the southern half of Saskatchewan. It contributes significantly to the social and economic well-being of the people of the region. During the early 1980s, several events led to increasing concern about the ability of the river to meet future needs.

The water resources of the South Saskatchewan River are intensively used by Alberta. Alberta irrigates more than a half million hectares of land in its portion of the basin. During the mid-1980s, Alberta completed a planning study which identified a range of future development options. Several of the options provided for significant expansion of irrigation which would further reduce the amount of water passed to Saskatchewan.

Since its joint development by the federal and provincial governments, more than 20 years ago, Lake Diefenbaker has become a focus for development in the Saskatchewan portion of the basin. This multi-purpose reservoir supports irrigation, hydro-electric energy generation, recreation, industrial and municipal water supply. In Saskatchewan, plans were also laid during the 1980s for further development based on the water resources of the South Saskatchewan River, particularly Lake Diefenbaker.

These plans included significant irrigation development. At the same time, proposals were made to further develop the recreation potential of the reservoir. Such developments would place additional demands on the water resources of the South Saskatchewan River.

While further development was being considered for the South Saskatchewan River Basin in both Alberta and Saskatchewan, there were several drought years in the 1980s. The droughts led to increased demand for water while the supply was reduced. In Saskatchewan, this caused problems for most water uses. There was concern regarding the ability of Lake Diefenbaker to support continued development. Weed growth at the upstream end of Lake Diefenbaker also led to concerns that the high quality water in Lake Diefenbaker was at risk.

The possibility of increased development, coupled with a reduced supply, led to greater concern about diverting water from the basin. Prior to the study, there had been a number of options identified for increased diversion of water from the South Saskatchewan River. However, when such diversions were identified, existing users expressed concern about the possible impacts. There was a clear need to determine the importance of the water in the basin to existing and future users.

The Canada-Saskatchewan South Saskatchewan River Basin Study was undertaken to provide information to guide water management. It will help ensure that the water resources of the basin can meet the needs of existing and future users.

1.2.1 The Study Agreement

On May 16, 1986, Federal Environment Minister Tom McMillan and Minister Responsible for SaskWater, Eric Berntson, signed the Canada-Saskatchewan South Saskatchewan River Basin Study Agreement. The agreement set aside 1.6 million dollars for the study with expenses shared equally by SaskWater and Environment Canada. The agreement established policies and procedures for a study of the Saskatchewan portion of the South Saskatchewan River Basin.

The Agreement identified three objectives for the study:

(a) "document the current and emerging water and related issues in the South Saskatchewan River Basin in Saskatchewan;

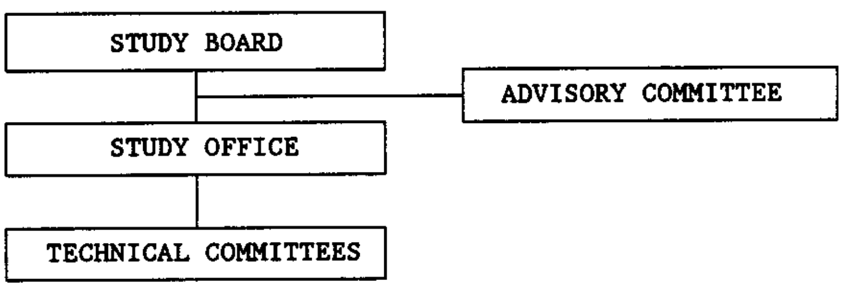
(b) "carry out an assessment of the water and related resources of the South Saskatchewan River Basin, and their current and future use;

(c) "develop a framework plan for the conservation and management of the water in the South Saskatchewan River Basin in Saskatchewan which allows for the evaluation of water resource projects."

1.2.2 Study Organization

The South Saskatchewan River Basin Study Board was responsible for the completion of the study. The board had one representative from each of the two sponsoring agencies: Environment Canada and SaskWater.

STUDY ORGANIZATION



An advisory committee provided policy information to the study board. Senior officials, representing agencies with water management responsibilities or interests in the basin, made up the advisory committee.

The study board set up the South Saskatchewan River Basin Study Office and staffed it with a director, assistant director and secretary. The director was responsible to the study board for the day-to-day administration of the study.

Technical committees assisted the study office. Representatives for the committees were drawn from agencies with responsibilities for water management. The agencies included federal and provincial departments, crown corporations and municipalities.

The technical committees provided the study office with expert advice on water quantity, water quality, water use and public involvement. A management strategies technical committee was responsible for drawing together the information produced by the other technical committees and identifying management options.

The technical committees also helped develop terms of reference for work carried out by consultants. More than 20 different consultants participated in the study. The consultants played a role in compiling the basic information needed to carry out the study.

PARTICIPATING AGENCIES

Environment Canada
SaskWater

Agriculture Canada
  Agri-Food Development Branch
  Prairie Farm Rehabilitation Administration
Western Economic Diversification

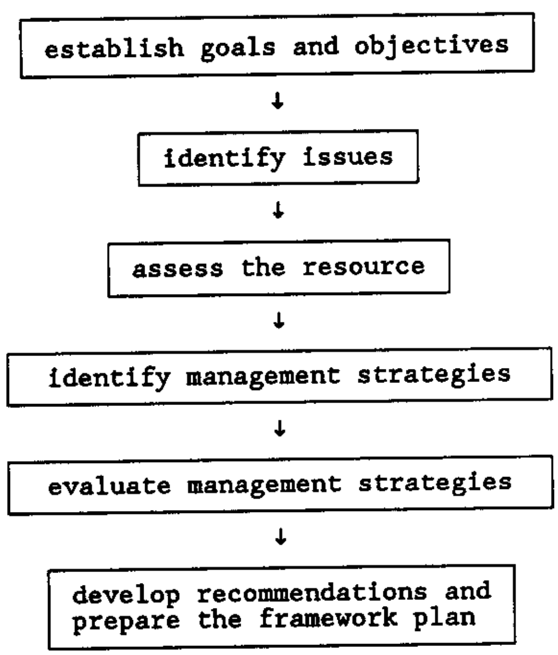
Saskatchewan Environment and Public Safety
Saskatchewan Parks and Renewable Resources
Saskatchewan Culture, Multiculturalism and Recreation
Saskatchewan Rural Development
Saskatchewan Agriculture and Food

SaskPower
City of Saskatoon
Meewasin Valley Authority

1.2.3 Planning Process

Early in the study, the study board defined the planning process and eight planning principles. These principles guided the study.

THE PLANNING PROCESS



PLANNING PRINCIPLES

THE WISE AND EFFICIENT MANAGEMENT AND USE OF WATER SHOULD BE PROMOTED THROUGH ALL POSSIBLE MEANS.

THE ECOLOGICAL INTEGRITY OF WATER RESOURCE SYSTEMS SHOULD BE MAINTAINED.

PUBLIC INVOLVEMENT IS ESSENTIAL FOR THE STUDY TO ACHIEVE ITS OBJECTIVES.

ALL WATER USES THAT HAVE SOCIAL, ECONOMIC OR ENVIRONMENTAL VALUE SHOULD BE CONSIDERED.

DOMESTIC WATER USE SHOULD BE THE HIGHEST PRIORITY AMONG ALL USES.

THE WATER RESOURCES OF THE BASIN SHOULD BE MANAGED FOR THE BENEFIT OF ALL PEOPLE IN THE PROVINCE.

WATER RESOURCES SHOULD BE DEVELOPED AND MANAGED CONSISTENT WITH THE CONCEPT OF SUSTAINABLE DEVELOPMENT.

INTERPROVINCIAL SHARING OF WATER IS BASED ON THE MASTER AGREEMENT ON APPORTIONMENT.

The planning process included the use of a base year as the reference point for the analysis of future conditions. The base year for the South Saskatchewan River Basin Study was 1986 – the year the study began.

There were three separate planning exercises undertaken. They related to three different time horizons. The short-term planning exercise focused on the year 2000 and dealt with water management issues in the basin. The long-term planning exercise looked at the year 2020 and established a range of development options. The third and final planning exercise was the system-limit. It helped put the long-term planning exercise in perspective by identifying the development limits of the basin.

There are three main components to the study area: Mainstem South Saskatchewan River, Saskatoon Southeast Water Supply (SSEWS) system and Swift Current Creek. Although water management in these components is interrelated, the interrelationships are minor. Therefore most aspects of the study considered each component separately. The mainstem includes the South Saskatchewan River from the Alberta border to the confluence with the North Saskatchewan at the downstream end of the study area. Lake Diefenbaker is included in the Mainstem component. The effects of actions on this mainstem area on the Saskatchewan River downstream of the study are were also considered in the mainstem section of the study. For this study, the SSEWS system was considered to include all of the works downstream of the East Side Pump Station near Gardiner Dam on Lake Diefenbaker. The Swift Current Creek Basin includes the Rushlake Creek Basin.

1.3 SYSTEM DESCRIPTION

The following is a brief introduction to the water resources of the study area. More details are provided in the body of this report and in the other reports of this series.

1.3.1 Mainstem

The South Saskatchewan River rises in southern Alberta where it receives runoff from about 120 000 km^2 of drainage area. A portion of this drainage basin is located on the eastern slopes of the Rocky Mountains and foothills. This portion is a highly productive runoff area, producing virtually all of the flow received at the Alberta - Saskatchewan border where the average annual natural flow is 9 200 000 dam^3. This natural flow has ranged from lows of about 4 800 000 dam^3 in dry years to 16 000 000 dam^3 in wet years. On average, about two-thirds of the runoff occurs in the May to August period and less than 10 percent occurs in the December to March period.

In Alberta the water is used for irrigation, municipal, industrial, hydro-electric, fish, wildlife and recreation uses. On average, the flow is reduced by about 1 900 000 dam^3 per year, with irrigation taking about 95 percent of the water.

In Saskatchewan the river flows through a region of very low runoff. On average, the local runoff augments the natural flow by about 2 percent with half of this local flow originating in Swift Current Creek. Figure 1 shows the drainage area in Saskatchewan.

The largest water uses in Saskatchewan are centred around Lake Diefenbaker and the city of Saskatoon. Total water consumption averages about 500 000 dam^3 per year. Evaporation from Lake Diefenbaker accounts for about half of this total, irrigation is the second largest user and municipal and industrial users take a relatively small portion of the flow. Although less than 10 percent of the water is consumed, the remaining water is used for important instream purposes, including hydro-electric generation, recreation and fish and wildlife.

Downstream of the study area the South Saskatchewan River joins the North Saskatchewan River and their combined flow continues east in the Saskatchewan River. Within Saskatchewan the flow is used to generate electric energy at the Nipawin and E. B. Campbell Power Stations. Downstream of the Saskatchewan - Manitoba border, the Grand Rapids Power Station uses the river before the water discharges to Lake Winnipeg. At Lake Winnipeg the water joins other flows from the south and east as it flows down the Nelson River to Hudson Bay. Along the Nelson River, there are additional power stations. In addition to the power stations the rivers downstream of the study area serve as local transportation routes, provide habitat for fish and wildlife and serve the water supply needs of several communities.

The quality of the water in the mainstem is very good, meeting the requirements of all of the existing and projected users. Upstream of Lake Diefenbaker the quality varies from season to season with the rate of flow. In the lake, however, the seasonal variations are mixed, producing a very uniform quality downstream. Within the study area the greatest pollution threat arises from municipal and industrial effluents in the Saskatoon area where effluent treatment requirements are regularly under review.

1.3.2 SSEWS System

The SSEWS is a manmade water delivery system which draws water from Lake Diefenbaker and delivers it to an area northeast of the lake as far as Lanigan as shown on Figure 2. The major uses of the water are irrigation, industries, municipalities, recreation and wildlife. The largest irrigation project is the South Saskatchewan River Irrigation District which serves over 16 000 ha. Potash mines are the main industrial users.

The quality of the water at the upstream end of this system is equal to the mainstem, since it is drawn from Lake Diefenbaker. As the water moves downstream in the system, local surface and ground water inflows of less desirable quality are added and evaporation concentrates impurities resulting in a lower quality of water. The quality is satisfactory for the uses made of it, but is less than ideal.

1.3.3 Swift Current Creek

Swift Current Creek is the largest tributary to the mainstem in Saskatchewan. This creek drains a portion of the Cypress Hills as shown on Figure 3. The average natural flow is about 80 000 dam^3 and the annual flow ranges from about 20 000 dam^3 to 265 000 dam^3.

Swift Current Creek water is used for irrigation and as a source of supply for municipal water at the city of Swift Current and the village of Herbert. The irrigation and municipal systems rely on Duncairn Reservoir for flow regulation to overcome natural periods of low flow. The water supply system from Swift Current Creek extends to areas of the neighbouring Rushlake Creek Basin. In addition to the consumptive water uses, the water of this creek is used for recreation, fish and wildlife. Although the quality of the water in this area is not as good as that in the mainstem, it has been satisfactory for the current uses.

FIGURE 1 THE STUDY AREA

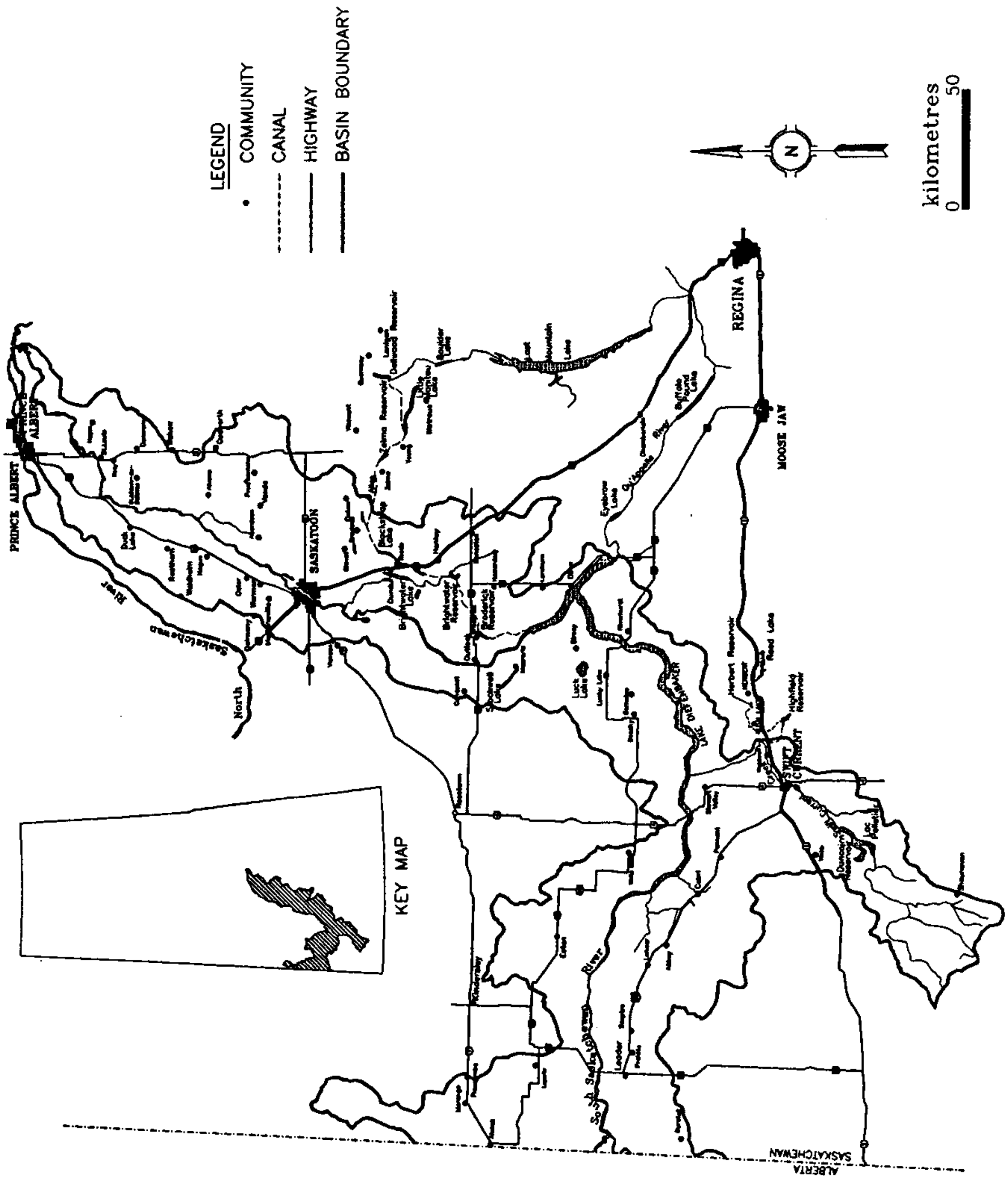


FIGURE 2 SASKATOON SOUTHEAST WATER SUPPLY SYSTEM

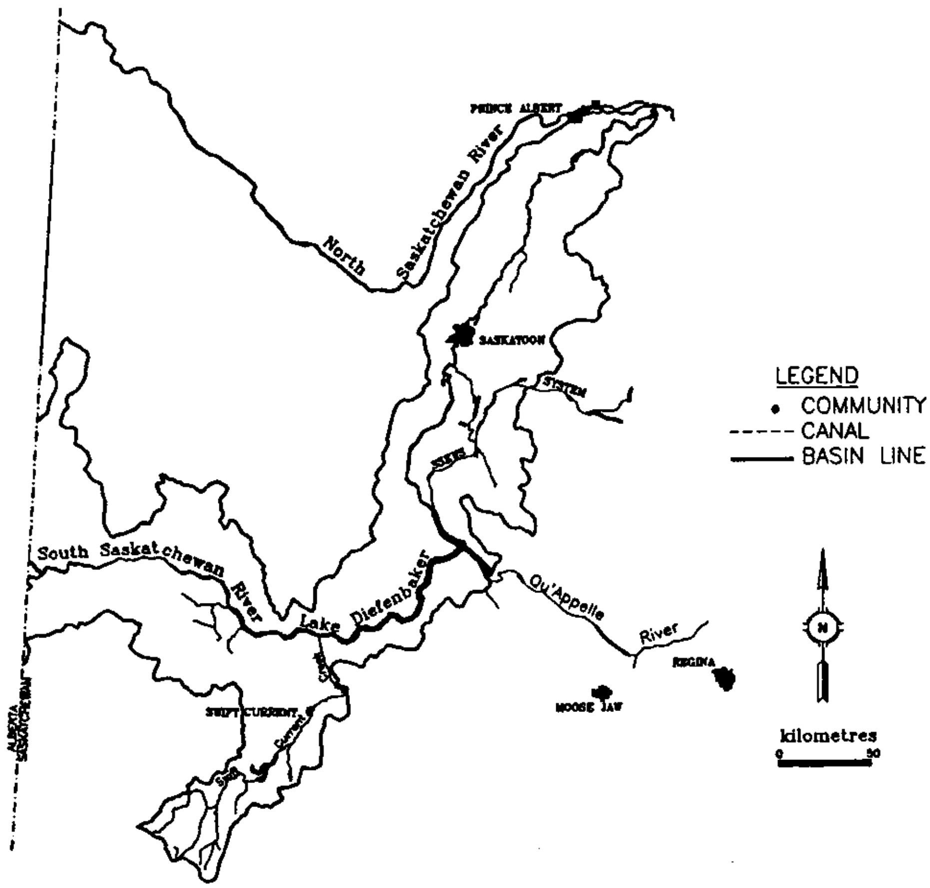
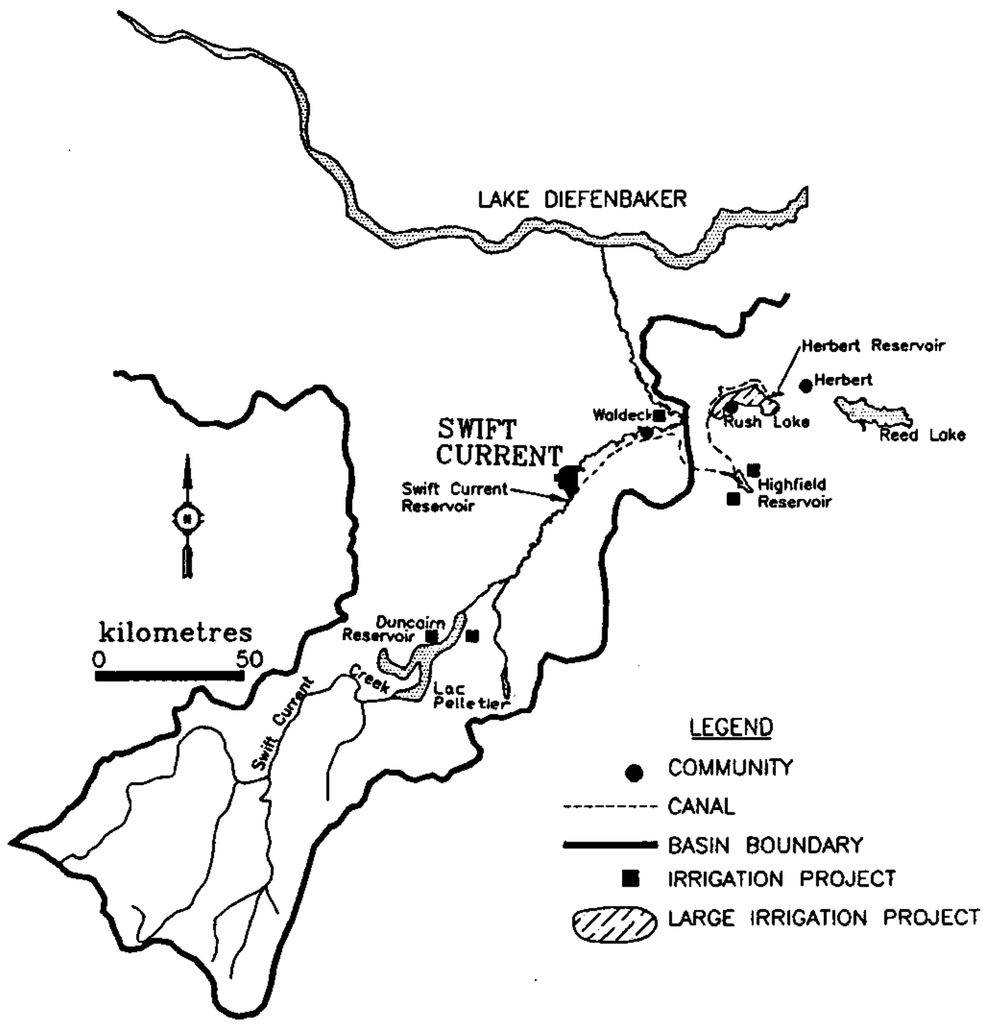


FIGURE 3 SWIFT CURRENT CREEK



2.0 INFORMATION ACQUISITION AND PRESENTATION

2.1 INFORMATION ACQUISITION

Previous studies undertaken for the Canada-Saskatchewan South Saskatchewan River Basin Study (SSRBS) were reviewed and key information abstracted. These studies included an evaluation of fisheries (SSRBS Technical Report D.8) and heritage resources (SSRBS Technical Report E.16).

For the other topics addressed in this report, numerous published and unpublished documents and files were consulted. These included documents and files from Saskatchewan Parks and Renewable Resources, Canadian Wildlife Service, Saskatchewan Natural History Society and Ducks Unlimited Canada.

To supplement the document review, interviews were also conducted with representatives of the Saskatchewan Wildlife Federation.

2.2 INFORMATION PRESENTATION

Map-related data were digitized and portrayed with the aid of a pc-based version of Arc/Info Geographic Information System (GIS) software. Critical wildlife habitat, land tenure and land system (environmentally sensitive areas) were digitized at 1:250 000 scale from the Province of Saskatchewan's Terrestrial Wildlife Habitat Inventory maps that were produced during the period 1976 to 1983. Hydrography, including wetlands, was digitized from Energy, Mines and Resources Canada, 1:250 000 scale National Topographic Series maps. International Biological Program natural areas were derived from Adam (1985) and digitized at 1:250 000 scale.

Major highways and urban centres were digitized from the 1:1 000 000 scale map of Saskatchewan produced by Saskatchewan's Central Surveys and Mapping Branch. The South Saskatchewan River Basin boundaries and heritage resource information were digitized from a 1:1 000 000 hard copy plot provided by the Study Office.

Point source data were also collected from a variety of sources. Ducks Unlimited Canada provided their project locations referenced to Universal Transverse Mercator (UTM) coordinates. Ferruginous hawk, piping plover and burrowing owl nest locations were provided by Canadian Wildlife Service and Saskatchewan Parks and Renewable Resources to the nearest 1/4 section of land. Priority duck and goose staging and moulting habitat information was derived from published documents (e.g. Canadian Wildlife Service 1979).

The available information came in two map projections - Lambert Conformal Conical and UTM. The projections were transformed to a Mercator Projection in metres, with the central meridian defined as 106° and 52° N defining the latitude of true scale. The Mercator Projection was used for all map output and analysis. The derived information is portrayed in a series of maps contained within the map folios found at the end of the document.

3.0 WATERFOWL

Prairie Canada with its mosaic of wetlands and upland habitat, constitutes an exceptionally important component of the continent's waterfowl production. Roughly one-third of agricultural Saskatchewan is comprised of high-potential waterfowl habitat. Virtually all of the study area is located in the Grassland and Parkland ecoregions with a very small proportion located in the Southern Boreal ecoregion (Rowe 1977).

The Western and Northern Region of Canada (Alberta, Saskatchewan, Manitoba and the Northwest Territories) has produced on average approximately 31 million ducks per year for the period 1955 to 1983. The largest individual jurisdictional contribution comes from southern Saskatchewan, which typically contributes 28 percent (8.7 million ducks annually) of the Western and Northern Region totals (Canadian Wildlife Service 1986).

The study area supports a broad diversity of waterfowl during both the breeding period and migration. Dabbling duck species such as the mallard and blue-winged teal represent the most common breeding waterfowl, although diving ducks such as lesser scaup are also relatively common (Bellrose 1976, 1979). Breeding Canada geese are also becoming increasingly abundant throughout the region. The study area lies within the Mississippi and Central flyways, major migration corridors for waterfowl (Linduska 1964). As a result, virtually all North American species of ducks may frequent the study area during migration. Various goose species, notably the Canada goose, greater white-fronted goose and lesser snow goose also frequent the study area in large numbers during migration. Tundra swans are also common migrants here.

The North American Waterfowl Management Plan (NAWMP), a comprehensive land use and wildlife habitat management plan involving both the United States and Canada, was designed to protect waterfowl populations in North America, which have been generally decreasing over the last three decades. The plan has identified the prairie pothole region as the area of greatest importance for continental northern pintail and mallard populations (NAWMP n.d.). The Prairie Habitat Joint Venture (PHJV) was formulated to identify key zones within this region and recommend the necessary strategies aimed at restoring waterfowl populations to levels found during the early 1970s (NAWMP 1989). A considerable portion of the study area is located within several of the NAWMP Key Program Areas identified by the PHJV. These areas include parts of the Allan-Tiger-Minichinas Hills (immediately east and south of Saskatoon) and the Missouri Coteau Key Areas (an area running in a northwest to southeast direction from north of Swift Current to south of Weyburn; NAWMP 1989). From the perspective of waterfowl, the mosaic of temporary, seasonal and permanent wetlands and adjacent uplands found in these program areas have historically supported the highest concentrations of breeding ducks in North America.

In terms of general waterfowl biology considerations, migrating ducks and geese arrive in this region of Saskatchewan in April and early May, with geese representing the earliest migrants. Migrating waterfowl, including those on staging areas, are typically loosely assembled in flocks. These staging areas are characterized by shallow melt-water areas or wetlands with a broad expanse of open water. During spring migration, waterfowl frequently feed on waste grain from the previous years' crop. Resident birds disperse to an assortment of wetland types shortly after their arrival. Optimum breeding habitat for most waterfowl consists of an interspersion of temporary wetlands, shallow marshes and open water wetlands, with the preferred habitats being seasonal or permanent pothole wetlands (Stewart and Kantrud 1973, Weller and Fredrickson 1974, Voigts 1976, Dwyer et al. 1979, Kaminski and Prince 1981, Nietfeld et al. 1984). A good interspersion of open water and emergent and submergent vegetation in these wetland complexes is also important (Kaminski and Prince 1981). As some waterfowl species such as the mallard may occupy 7 to 22 wetlands during the breeding period (Dwyer et al. 1979), high wetland densities are important in maintaining breeding waterfowl numbers within a region. Shallow, temporary wetlands are particularly important to many waterfowl species as they are the first to develop abundant invertebrate populations, an energy-rich food source for migrating, nesting and breeding waterfowl (Joyner 1980, Kantrud and Stewart 1984). Failure of this food source, as a result of droughts or extensive wetland drainage, can result in significant reductions in nesting success, even though permanent water and nesting cover may be present (Lietch 1964, Smith 1969).

Nesting may span a period from late April to early July, depending on the onset of spring weather and the frequency of second nesters (i.e. hens that renest after failure of their first clutch). Nests are frequently located in upland areas, away from the main waterbodies, with some species such as mallards flying relatively long distances (e.g. 1.6 km) from wetlands to nest sites (Duebbert and Lokemoen 1976). Undisturbed dense grass and herb cover, interspersed with shrubs provides preferred nesting cover for many species (Dwernychuk and Boag 1973, Duebbert and Lokemoen 1976). Tillage, grazing and burning, particularly within 500 m of wetlands, removes all or most of the residual nesting cover for waterfowl, and can drastically reduce nesting success within a local area.

Once broods have hatched, relatively permanent water is necessary for their survival. Seasonal and permanent wetlands, at least 0.5 to 1.0 ha in size, with vegetated shorelines are preferred for brood rearing for many species (Berg 1956, Lokemoen 1973, Hudson 1983). Loafing sites such as muskrat houses, low mud or sand bars and logs are highly favoured by duck broods and may be a factor in determining brood use (Beard 1964). Broods often travel to several different waterbodies in order to meet their food and cover requirements (Bellrose 1976, Duebbert et al. 1983). Invertebrates such as snails, amphipods, and a wide variety of aquatic insects make up an important component of the diet of ducklings, and are generally most abundant in areas with dense submergent and emergent vegetation (Collias and Collias 1963, Sugden 1973, Krapu and Swanson 1975, Danell and Sjoberg 1977).

Dispersal to moulting areas is common among post-breeding waterfowl (Hochbaum 1955, Salomonsen 1968). Post-breeding habitat requirements vary from species to species but generally consist of large waterbodies (>50 ha) with a stable food source (Oring 1964, Kortegaard 1974, Gilmer et al. 1977, Bailey 1983). Fall migrating waterfowl frequent the South Saskatchewan River Basin region from mid-August until freeze-up. Again, habitat requirements vary from species to species, but larger waterbodies in close proximity to cereal crop production areas generally receive the greatest utilization (Bossenmaier and Marshall 1958, MacLennan 1973).

As indicated on Tables 1 and 2 and in the wildlife resources map folio, numerous waterbodies in the study area are recognized as priority areas for waterfowl staging and moulting (CWS 1979, Poston et al. 1990). This priority designation (i.e. an area of local, regional or national importance) includes portions of the South Saskatchewan River itself, specifically the stretch of river immediately upstream of Lake Diefenbaker (CWS 1979, SSRBS Technical Report E.7, Gollop 1990, Poston et al. 1990). This portion of the river is of national importance for duck and goose staging (Poston et al. 1990). For example, the single most important staging area for greater white-fronted geese in Canada is located between the Red Deer/South Saskatchewan River Forks and Lake Diefenbaker (SSRBS Technical Report E.7, Poston et al. 1990). During the period September 25-28, 1990, Gollop (1990) estimated 550 000 geese were frequenting the South Saskatchewan River between Lancer Ferry (south of Eston) and Galloway Bay (west of Kyle). Gollop (1990) suggests classifying the reach from Lancer Ferry to the mouth of Antelope Creek as continentally critical for staging greater white-fronted geese and sandhill cranes, and regionally important for other staging geese. The sandbar formations in the river provide preferred roosting sites for staging waterfowl. The reaches downstream of the Gardiner Dam also provide extensive sandbar formations and may also experience high waterfowl utilization (SSRBS Technical Report E.7).

TABLE 1	STAGING AND MOULTING WETLANDS FOR DUCKS AND GEESE IN THE SOUTH SASKATCHEWAN RIVER BASIN	
WETLAND	USAGE	IMPORTANCE VALUE
Luck Lake	Goose Staging Duck Staging	National Local
Snipe Lake	Goose Staging Duck Staging Duck Moulting	Regional Local Local
Anerley Lakes	Duck Staging Duck Moulting	Regional Local
Marengo Slough	Goose Staging Duck Staging	Regional Local
Loverna Slough	Duck Staging Goose Staging	Regional Local
Jumping Lakes	Duck Moulting	Regional
Cabri Lake	Duck Staging	Regional
Duck Lake	Duck Staging	Regional
Red-Top Slough	Goose Staging Duck Staging	Local Local
Pelican Lake	Duck Staging Duck Moulting	Local Local
Stockwell Lake	Duck Staging	Local
Indi Lake	Duck Moulting	Local
Blizzard-Scory Lake	Goose Staging	Local

Source: CWS 1979, Poston et al. 1990

TABLE 2	LIST OF DUCKS UNLIMITED PROJECTS IN THE SOUTH SASKATCHEWAN RIVER BASIN
PROJECT NAME	LOCATION (UTM)
Adams Slough	12-6100-56933
Amaranth	12-6190-57898
Anderson	12-6918-54933
Androsoff	13-3730-58469
Anglin Lake	13-4346-59495
Arnold	13-2945-55037
Aslin	12-6434-54683
Attraction	12-5979-54924
Baldwin	13-4136-57513
Barbers Lake	13-5572-57867
Barlow	13-4404-56857
Basin	13-3065-56377
Bellows	13-3133-56301
Blackstrap Marsh	13-4069-57491
Boggy Lake	12-6790-56050
Bramble Lake	13-3443-58380
Brown	12-7047-55027
Buchanan	13-6530-57285
Buffalo Coulee	12-6152-57362
Campbell	13-5749-57429
Campbell	13-4371-59203
Cancade	13-6869-55395
Candle and Torch Lakes	13-4896-59572
Canola	13-5130-58213
Carmen Lake	13-3868-58376
Centennial	13-3899-57285
Chaplin	13-3874-55793
Cheal Lake Complex	13-4574-59199
Christopher	13-4425-59214
Clavet	13-4070-57548
Coldwater	12-7109-54915
Coldwell Creek	13-4877-58486

TABLE 2 LIST OF DUCKS UNLIMITED PROJECTS IN THE SOUTH SASKATCHEWAN RIVER BASIN

PROJECT NAME	LOCATION (UTM)
Court Keewaters	12-5776-57495
Coyote	13-3115-56294
Crawford Lake	13-4129-57674
Czychowski	13-4531-59229
Double Eagle	12-6580-54346
Duck Lake	12-6260-54792
Dundurn	13-3953-57396
Duval	13-5129-56715
Eagle Lake - Melfort	13-5272-58328
Eaglehill	12-6504-57988
Eaglehill Lake	12-6406-58019
Ear Lake	12-6196-57898
East Stinking Lake	13-5226-58435
Eastend Keewaters	12-6494-54766
Elstow	13-4178-56566
Elva Lakes	13-4142-57514
Emde	13-4697-56819
EPP (Mellow)	13-4071-57523
Ernfold Potholes	13-3664-55879
Evan Lake	13-5029-58288
Eyebrow Marsh	13-4196-56414
Farish	13-3003-56346
Flat Lake	13-4839-58987
Floral	13-3960-57694
Flynn	13-3177-55306
Frisk	13-3163-56285
Gamble	13-3226-57544
Garrison	13-4836-59262
Gary Group	13-3160-57864
Grassy Creek	12-6942-55068
Gravenhurst	12-6518-57171
Grill Lake	12-6287-57866

TABLE 2 LIST OF DUCKS UNLIMITED PROJECTS IN THE SOUTH SASKATCHEWAN RIVER BASIN

PROJECT NAME	LOCATION (UTM)
Gull Lake	12-6796-55536
Haakensen	13-2950-55033
Hanson Lake	13-5283-58780
Harvey	12-6776-55616
Hawker	13-3737-57682
Hesla	13-2922-56342
Himour	13-3164-55821
HO-42-26-2-1 Wakonda	13-4549-58317
Hoffman	12-5864-57302
Hoosier	12-5868-57255
Hounjet	13-4327-57815
Hummock Isle	12-7096-54971
IN-44-24-2-1 Turgeon	13-4745-58504
Indi Lake	13-3967-57290
Innes	12-6409-54715
Insinger	13-6357-57120
Instow	12-6949-55274
Instow Lake	12-6977-55128
Ivan	13-2917-56409
Kernaleguen	13-5146-58217
KI-47-22-2-5 Neider	13-4869-58771
KI-47-22-2-3 Hansen	13-4868-58803
KI-47-22-2-1 Robertson	13-4855-58800
KI-47-22-2-2 Hadland	13-4905-58800
KI-47-22-2-4 Oakenfold	13-4852-58803
Kindersley	12-6096-57071
Klintonel	12-6596-55052
Kozicki	12-6181-56935
Kronberg	12-6893-55004
Kyle Keewaters & Extension	13-3095-56545
Lake Lenore Rearing Pond	13-4982-58102
Lease	12-6322-54632

TABLE 2 **LIST OF DUCKS UNLIMITED PROJECTS IN THE SOUTH SASKATCHEWAN RIVER BASIN**

PROJECT NAME	LOCATION (UTM)
Legge	12-6944-57123
Lindo-Neville	13-3128-55388
Lizard Lake	13-2904-55350
Long Lake	13-4900-58529
Loucks	13-3036-56331
Lovedale	12-6523-56976
Luck Lake	13-3505-56608
Luseland	12-6104-57654
Mackie	12-7062-55036
Makaroff-Boulanoff Complex	13-3718-58588
Margent	12-6840-55650
Marten	13-3098-55939
Marten "B"	13-3108-55939
Matador	13-3108-56286
Matthews	13-3143-55278
Maude Lake	13-4984-58303
McCraney & Extension	13-4389-56903
McFarlane Creek	13-4394-58786
McKeith Dam	13-3474-55096
McVicar	13-4308-57282
Meacham	13-4403-57743
Melland Potholes	13-2938-56432
Merrison	13-3013-56395
Middle Eagle	12-6472-58011
Milden	13-3239-57033
Millie	12-6358-55844
Mine (Minor Lake)	12-6520-57116
Moat	12-6885-55538
Moncrieff	12-5921-58218
Mullberry	12-6311-57918
Murfitt	13-4828-56987
Myron	12-6920-54909

TABLE 2	LIST OF DUCKS UNLIMITED PROJECTS IN THE SOUTH SASKATCHEWAN RIVER BASIN
PROJECT NAME	**LOCATION (UTM)**
Nabe Project	13-3183-56919
Neidpath	13-3389-55662
Norona Lake	13-5062-58232
North Creek Marsh	13-3416-59247
Ohmacht	13-3029-56376
PA-47-25-2-3 Placsko-A	13-4573-58886
PA-47-25-2-4 Placsko-B	13-4608-58880
PA-47-27-2-4 Blocka	13-4408-58862
PA 46-27-2-1 Georget R	13-4380-58798
PA 47-26-2-4 Pokraka	13-4506-58845
PA 47-27-2-5 Georget J	13-4423-58814
PA-47-25-2-1 Larionyk	13-4540-58851
PA-47-25-2-2 Barden	13-4545-58825
PA-47-26-2-1 Samson A	13-4477-58890
PA-47-26-2-2 Samson B	13-4471-58890
PA-47-26-2-3 Bibby A	13-4457-58843
PA-47-26-2-5 Sheldon	13-4473-58861
PA-47-26-2-7 Fremont	13-4490-58860
PA-47-26-2-8 Bibby-B	13-4457-58876
PA-47-27-2-2 Shillington	13-4691-58831
PA-47-27-2-3 Korpess	13-4415-58820
PA-48-26-2-1 Bundon	13-4474-58912
Pathlow North	13-5195-58404
Pathlow South	13-5190-58379
Pelican North	13-4518-58486
Penner Slough	13-4832-57298
Perdue	13-5113-58140
Perrin	13-3107-56278
Peter Lake	13-5077-57024
Peterson	12-7148-55152
Phalen	12-6922-55026
Phelps	12-6703-58238

TABLE 2 LIST OF DUCKS UNLIMITED PROJECTS IN THE SOUTH SASKATCHEWAN RIVER BASIN

PROJECT NAME	LOCATION (UTM)
Piapot Dam	12-6367-55385
Pine View	12-6019-54917
PL-41-17-2-1 Semple-McPhail	13-5443-58215
Polichuk	13-3133-58728
Pollon	13-5328-57279
Ponass Lake	13-5695-57827
Poppy	12-6957-55015
Porter	13-4914-58385
Postnikoff	13-3635-58528
Prairie	13-4921-57005
Pratt	12-6439-54788
Proctor Extension	13-3880-57300
Proctor Lake	13-3866-57286
Prud'Homme	13-4387-57973
Quaroni	13-5219-58280
Rabbit Lake	13-2915-54978
Radisson Restriction	13-3362-58180
Ranch North	13-5163-58197
Range Slough	13-5144-58174
Rangeland	13-3146-56543
Rat Tail	13-3037-56362
Rath	13-5072-57910
Raven	13-4979-58125
Rebin	13-3715-58452
Redberry Lake	13-3576-58474
Redding	13-3323-57355
Resources	13-3136-57823
Reynaud	13-4707-58278
Rice Lake	13-3545-57681
Rice Lake Restriction	13-3540-57664
RM 248-Touchwood	13-5580-56655
RM 278-Kutawa	13-5557-56979

TABLE 2	LIST OF DUCKS UNLIMITED PROJECTS IN THE SOUTH SASKATCHEWAN RIVER BASIN
PROJECT NAME	**LOCATION (UTM)**
RM 279-Mount Hope	13-5190-56675
RM 308-Big Quill	13-5554-57175
RM 309-Prairie Rose	13-5258-57235
RM 338-Lakeside	13-5548-57528
RM 339-Leroy	13-5257-57525
RM 368-Spalding	13-5533-57819
RO-41-4-3-1 (Wagner)	13-3949-58223
RO-41-4-3-2 Wagner Land Purchase	13-3949-58224
Robinson Creek	13-3088-59446
Rogers	13-2962-56049
Ronellenfitsch	13-4749-58210
Rosdahl	12-6246-54633
Rose Lynn	12-6138-57630
Roseberry	13-3410-58389
Ross	12-6948-55548
Ross Afseth	13-3524-57686
Roufosse Marsh	13-5601-58051
Round Lake	12-6429-54545
Round Valley	12-6988-58695
Rudy	12-6509-58683
Running	12-7130-54965
Rush Lake Marsh	13-3120-55734
Saganski	13-3537-58546
Sage Creek	13-3827-56499
Saline Creek	13-4952-56955
Salvage	12-6352-57530
Saskatoon Keewaters	13-4003-57687
Sautner	12-5976-56996
Scansen	13-2925-55018
Scheilenberg	13-3863-57163
Seafoot	12-6948-55048
Seagram Lake	12-6132-58262

TABLE 2	LIST OF DUCKS UNLIMITED PROJECTS IN THE SOUTH SASKATCHEWAN RIVER BASIN
PROJECT NAME	LOCATION (UTM)
Senger	13-4177-57497
Sharp Lake	13-3586-59743
Shaunavon	12-6852-55016
Shellstone Reservoir	13-3654-56276
Shields	13-4877-56995
Shumlick	13-3111-58707
Sibley	13-3010-58631
Sidewood Marsh	12-6470-55468
Simpson	13-2992-56372
Simpson	13-4812-56946
SL-43-27-2-2 Fisich	13-4443-58424
SL-43-28-2-1 Kulyk	13-4355-58355
Slough Creek "A" and "B"	13-5484-58259
Smiley	12-6986-54400
Snipe Lake	12-6503-56789
Snyder	12-6689-58352
Spoonbill	12-6482-55412
St. Benedict	13-4724-58281
St. Brieux	13-5088-58374
Stalwart Flats	13-4724-56720
Stalwart Marshes	13-4708-56753
Stanleyville Dam	13-4687-58872
Steinley	12-5765-56657
Still	13-3402-58664
Stone Kee-Waters	12-6578-55237
Stony Vista	12-6159-56837
Strap Lake	13-4487-57377
Strom	12-7020-56331
Sucker Lake Complex	13-4105-59174
Sutton	13-5417-57331
Swan	12-6684-55412
Swift Current Keewaters	13-3113-55758

TABLE 2	LIST OF DUCKS UNLIMITED PROJECTS IN THE SOUTH SASKATCHEWAN RIVER BASIN
PROJECT NAME	**LOCATION (UTM)**
Tarnopol	13-4689-58385
Tenaille Lake	12-6063-55515
Thackeray Lake	12-6582-58265
Thatch Creek East	13-5269-58432
Thatch Creek West	13-5252-58413
The Marsh	13-3386-59086
Thierman	12-7052-55634
Thunder Creek Land Purchase	13-3412-56140
Thunder Creek South	13-3413-56141
Thunder Creek Water Agreement	13-3412-56141
Torwalt	13-5513-59464
Touchwood Hills (NAWMP)	13-5500-57120
Tuer	12-6675-58319
Tugaske	13-4013-56334
Turner	13-5172-57116
Turuk	12-6734-58489
Tway Lake	13-4739-58472
Twelve Mile Lake	13-4061-54801
Twin Island	13-2994-56332
Urwin	13-3058-56375
Usborne & Extension	13-4803-57241
Vant Creek	13-4065-59068
Vimy (Arkansas - Vimy)	13-5209-57139
Viv	13-3115-57756
Vonda Lagoon	13-4267-58007
Walsh Keewaters	12-5910-54975
Ware Memorial	13-5070-58548
Wasyliw	13-4337-58828
Waterhen Marsh	13-4971-58578
Waterman	13-4530-57337
Watertown	13-4815-56900
WC 47-18-2-1 Lunde	13-5291-58830

TABLE 2	LIST OF DUCKS UNLIMITED PROJECTS IN THE SOUTH SASKATCHEWAN RIVER BASIN
PROJECT NAME	**LOCATION (UTM)**
WD-40	13-4420-57743
West Stinking Lake	13-5210-58425
Westley	13-3515-57672
White Gull Lake	12-6738-55469
White Heron Lake	12-6310-57543
Wilbert South	12-6262-58367
Wilbert South-Uplands	12-6265-58371
Wiley	12-6059-57913
Wiley Potholes	13-4126-57481
Wilhelm	12-6973-55565
Wilton	13-3366-57403
Witchekan South-East	13-3340-59185
WO-36-22-2-1 Reineke	13-4900-57760

The staging and moulting sites identified in Table 1 are widely distributed along the entire length of the study area, with priority areas being found from the Alberta/Saskatchewan border (e.g. Loverna Slough) northeast to the Jumping Lakes, approximately 50 km south of Prince Albert.

Much of the upland area within the South Saskatchewan River Basin, including those areas encompassing the wetlands noted in Table 1, have also been identified as being of national and/or regional importance for staging and moulting waterfowl (Poston et al. 1990).

The river is also of regional importance for Canada goose brood rearing from mid-May to early July. Duck broods also frequent the river but for a period that extends into August.

Ducks Unlimited Canada has constructed and operates 78 projects in the study area (Table 2, see also wildlife resources map folio). No projects are currently operating along the river itself (MacFarlane 1990), and as such all existing projects are considered to be offstream water users (SSRBS Technical Report E.7).

3.1 Waterfowl and Study Area Water Resources

Gollop (pers. comm. 1990) described how the suitability of the South Saskatchewan River for waterfowl is related to the water regime. For example, the reach from Cutbank north to the correction line west of Hanley is regionally important for goose and sandhill crane staging, and is also vulnerable to extremes in water management as the roosting habitat in the form of sandbars is subject to inundation during "high-release" periods. Similarly goose nests located on willow islands and sandbars would be inundated by high water during nesting which spans the period from early April to mid-May. Lake Diefenbaker is currently subject to variations in water levels that may amount to as much as 300 percent among years and as a result, projected decreases of 14 percent of average annual inflow from Alberta over the next 30 years are well within the historic range and therefore are unlikely to adversely affect waterfowl staging use of the river (M. Gollop, pers. comm. 1990). Plans are to operate Lake Diefenbaker in a manner which is similar to current conditions with the exception of a modest reduction in water drawdown as increased water demands dictate that less storage of spring run-off will be required. Gollop (pers. comm. 1990) considered that this would result in stabilization of lake levels and thereby encourage waterfowl use. SSRBS Technical Report E.7 identified some tentative recommendations for operation of Lake Diefenbaker for waterfowl staging during fall. Minimum, preferred and maximum elevations of 551.53, 553.32 and 556.58 m a.s.l. respectively, were indicated.

With regard to water management implications, drainage projects, with the associated loss of wetland habitat have the potential to adversely affect waterfowl habitat.

Providing that irrigation expansion does not entail the cultivation of grassland areas, which provide preferred waterfowl nesting habitat, then the irrigation is not expected to adversely effect waterfowl.

Conversely, water management has been used successfully as a waterfowl enhancement technique by agencies such as Ducks Unlimited (DU) for over 50 years to ensure an adequate breeding and brood water supply particularly during years of reduced natural water availability. Examples of the co-existence of irrigation projects and waterfowl are widespread in southern Canada (Young et al. 1984a, Sankowski et al. 1988, Young 1989). For example, Ducks Unlimited Canada projects in southeastern Alberta are almost entirely reliant upon irrigation water which is gravity fed from rivers in the Alberta portion of the South Saskatchewan River Basin. In Saskatchewan, both the Luck Lake and Riverhurst irrigation projects have Ducks Unlimited projects associated with them. Ducks Unlimited regularly works in conjunction with the irrigation districts to develop projects which benefit both livestock and waterfowl.

4.0 ENDANGERED SPECIES

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is an independent body with representation from provincial and federal governments which annually updates a list of wildlife, fish and plant species which are considered to be "at risk". This classification scheme, which is supported by the Province of Saskatchewan and the Government of Canada, was adopted for assembling the list of species upon which this document focuses.

Numerous species listed by COSEWIC (1990) (see Table 3) could occur in the study area but little site-specific data are available which has been assembled in a systematic manner. Furthermore, many of the wildlife species (e.g. whooping cranes) would frequent the South Saskatchewan River Basin only occasionally or briefly such as during migration. As a result, only those species for which basin-wide, systematic data are available are included in this discussion.

The classification "endangered" species is a designation which ranks third, only behind "extirpated" and "extinct", and just above "threatened" in the COSEWIC "at risk" classification scheme. "Endangered" is a designation for an indigenous species that is threatened with imminent extirpation or extinction throughout all or a significant portion of its Canadian range owing to human action (COSEWIC 1989). Examples of "endangered" species include the piping plover and whooping crane.

4.1 Piping Plover

The piping plover, an "endangered" species, is a medium-sized shorebird, similar in appearance to the more common killdeer. Its distribution in Canada is concentrated in the Prairie provinces although smaller numbers occur in the Atlantic provinces (Dale 1986, Godfrey 1986). Numbers of this species have evidently fluctuated dramatically over the last 100 years, from a point near extinction in the early 1900s to approximately 3 500 to 4 100 birds in North America in 1985 (Haig and Oring 1985). Within Saskatchewan, survey data generated by Harris et al. (1985) led Haig and Oring (1985) to estimate that Saskatchewan supported 700 - 1 200 Piping Plovers or 16 - 37 percent of North America's population. Harris et al. (1985) in fact suggested that Saskatchewan's piping plover population could number between 2 000 - 2 500 birds, with 1 430 individuals associated with surveyed lakes and an additional 500 - 1 000 birds frequenting scattered saline lakes, particularly in the area between the North and South Saskatchewan Rivers (Harris 1987). Dale (1986) summarized province-wide observations of piping plovers on breeding territories during 1984 and 1985; a total of 229 breeding territories was reported for Saskatchewan. This study of the South Saskatchewan River Basin revealed the presence of 71 piping plover breeding territories or 32 percent of the breeding territories Dale (1986) reported for Saskatchewan (Table 4). Most of these locations are on the shores of Lake Diefenbaker or on scattered wetlands near this lake (see wildlife resources map folio). The Thompson and McKenzie Arms provide the best habitat on Lake Diefenbaker although piping plovers are encountered at other locations on the lake (Sherratt and Kerr 1990).

The piping plover frequents beaches of lakes, saline wetlands and reservoirs (Renaud 1979, Haig and Oring 1985, D. Weidl, Pers. Comm.). Pebbly beaches constitute preferred nesting habitat, with adjoining shallow water providing foraging habitat. These birds usually nest within 100 metres of water and forage on invertebrates at the water's edge (Sherratt and Kerr 1990). Nesting and brood rearing occurs between late April and mid-August. Human-related disturbance of beaches either in terms of human presence during nesting or physical destruction of shoreline habitat is considered to be a factor leading to reductions in this species' numbers (Haig and Oring 1985).

4.1.1 Piping Plover and Water Management

Except for the operation of Lake Diefenbaker, water management activities or water resource developments in the study area should not affect the piping plover. The potential concern involves raising and holding water levels during spring at a point where nesting habitat would be inundated. Fluctuating reservoir levels are, nonetheless, important in the formation of beach habitat upon which nesting piping plovers are dependant. This occurs through inundating vegetation to remove it, filling deeper channels and widening the river channel (Sherratt and Kerr 1990). One could anticipate that there would be years when high water levels would adversely affect piping plover breeding effort but there would also be years when moderate and low water levels in a reservoir would provide good quality nesting habitat in the form of beaches. For example, in 1984, 223 plovers were observed on the Thompson and McKenzie Arms when water levels were low. In 1985, 50 pairs of piping plovers nested on the shores of Lake Diefenbaker in Danielson Provincial Park when water levels were also low (552.83 m a.s.l.). During 1986 when water levels were high (556.62 m a.s.l.), no piping plovers nested in this location (Sherratt and Kerr 1990, SSRBS Technical Report E.7). In 1990, 33 adults were observed during spring but no adults or young were encountered later in the summer, possibly as a result of water levels rising during the nesting season (Sherratt and Kerr 1990).

TABLE 3	A LIST OF COSEWIC - LISTED SPECIES AND THEIR STATUS IN THE SOUTH SASKATCHEWAN RIVER BASIN	
SPECIES	COSEWIC STATUS	STATUS IN BASIN
Prairie long-tailed weasel	Endangered	Year-round resident
Piping Plover	Endangered	Summer resident
Peregrine Falcon - subspecies anatum - subspecies tundrius	 Endangered Threatened	 Migrant Migrant
Whooping Crane	Endangered	Migrant
Baird's Sparrow	Threatened	Summer resident
Burrowing Owl	Threatened	Summer resident
Ferruginous Hawk	Threatened	Summer resident
Loggerhead Shrike	Threatened	Summer resident
Cooper's Hawk	Vulnerable	Summer resident
Eastern Bluebird	Vulnerable	Summer resident
Trumpeter Swan	Vulnerable	Migrant
Prairie Rose (Plant)	Vulnerable	Resident

TABLE 4	NUMBERS OF NESTING LOCATIONS FOR RARE/ENDANGERED SPECIES IN THE SOUTH SASKATCHEWAN RIVER BASIN
SPECIES	NUMBER NESTS/BREEDING TERRITORIES
Piping Plover	71
Ferruginous Hawk	104
Burrowing Owl	132

In the event that some flexibility exists in controlling the timing of reservoir level increases on reservoirs supporting breeding piping plovers, then it would clearly be desirable to minimize those increases during the reproductive period. Sherratt and Kerr (1990) have suggested that the most important management approaches are to periodically flood beaches to maintain that habitat and to avoid flooding wide beach habitat after the plovers have established their nests. Specific management measures recommended by Sherratt and Kerr (1990) include:

- Maintain stable reservoir water levels allowing for a minimum beach width of 100 metres on the Thomson and Gordon Mckenzie Arms during the breeding season (April 25 through August 15).

- Flood beaches of Lake Diefenbaker to eliminate vegetation once every three years during the non-breeding season.

- Flood sandbars downstream of Lake Diefenbaker during the non-breeding season once every three years to open up sandbars and maintain nesting habitat.

- Avoid increases in water flows downstream from Lake Diefenbaker between May 1 and August 15 as these could flood out nests or flightless young.

4.2 FERRUGINOUS HAWK

The ferruginous hawk is classified as a "threatened" species by COSEWIC (1990). "Threatened" is a designation for an indigenous species that is likely to become endangered in Canada if the factors affecting its vulnerability do not become reversed (op. cit.).

The ferruginous hawk is a large raptor that frequents grassland areas of the Prairie provinces. While this species nests throughout southern Saskatchewan, it is relatively uncommon (Smith 1987, Schmutz 1989), with approximately only 200 nesting pairs occurring in Saskatchewan as a whole (Smith 1987). Smith (1990) summarized Saskatchewan ferruginous hawk nest observations for the period 1966 - 1989 and reported 658 nest sites. Data abstracted from Smith (1990) for this study of the study area revealed 104 nest sites, although not all of these nest sites would be occupied in a given year because of this species' proclivity for using alternate nest sites from year-to-year (Table 4). These 104 nests represent approximately 16 percent of the nest sites reported for the Province by Smith (1990). These nests are distributed throughout the southern and central portions of the study area (see wildlife resources map folio).

Ferruginous Hawks nest in trees and on the ground, typically within grassland habitat (Olendorff 1973, Jasikoff 1982, Schmutz 1982, 1984). These birds are, however, also receptive to nesting in artificial nests and have nested successfully in these structures in a number of locations (Houston 1982, Millsap et al. 1987, Schmutz 1989, Schmutz et al. 1984). Extensive areas of grassland and the associated prey base (primarily Richardson's ground squirrels) provide optimal foraging habitat for this hawk (Houston and Bechard 1984, Schmutz 1989a).

The ferruginous hawk occupies a much reduced breeding range in the Prairie provinces. In Alberta, for example, ferruginous hawk breeding range has been reduced by approximately 40 percent while Saskatchewan has experienced a similar compression in this species' range (Houston 1979). Extensive cultivation and human disturbance have been shown to adversely affect the density of breeding ferruginous hawks. Ferruginous hawk abundance is strongly related to their primary source of prey, the Richardson's ground squirrel; intensive cultivation associated with a reduction in grassland results in reduced suitability of habitat for both the ground squirrels and hawks (Schmutz 1987, 1989a, 1989b).

4.2.1 Ferruginous Hawk and Water Management

From the perspective of water management activities and water resource developments, management of existing infrastructures would have little impact on ferruginous hawks. Future water resource development in the form of a new reservoir would have the most direct impact on the ferruginous hawk through the inundation of nesting and/or foraging habitat. Indirect impacts which have broader implications relate to expansion of the cultivated land base in grassland areas.

4.3 BURROWING OWL

Like the ferruginous hawk, the burrowing owl is classified as a "threatened" species by COSEWIC (1990). This small owl is also a largely grassland dwelling resident of Canada's Prairie provinces (Wedgwood 1978, Godfrey 1986). Estimates of this species' abundance vary considerably, with perhaps a maximum of 1 500 breeding pairs occurring in Saskatchewan, approximately 600 in Alberta and approximately 20 in Manitoba (Wedgwood 1978, Herriott 1989). Harris and Lamont (1985) reported records of 800 burrowing owl nest sites in Saskatchewan in 1984. Hjertaas (1990) provides records of 833 active nest sites in Saskatchewan based on surveys during the period 1987-1989. The South Saskatchewan River Basin Study extracted nest site observations from Hjertaas (1990) [see Table 4 and wildlife resources map folio]; 132 such sites or 16 percent of known nest sites in Saskatchewan were located in the study area. The reader is cautioned that because there are no annual, systematic surveys of the entire breeding range of this species in Saskatchewan, that the numbers quoted above are, for the most part, estimates. Furthermore, factors such as pesticide application may cause substantial, annual fluctuations in burrowing owl numbers (Herriott 1989).

The burrowing owl prefers to nest in grassland areas containing potential nest burrows in the form of abandoned burrowing mammal dens (Zarn 1974, Wedgwood 1978, Herriott 1989). With the intensification of agriculture in the Prairie provinces, this bird can, more and more, be found on isolated, small tracts of land such as farm yards. The burrowing owl diet is composed largely of insects such as grasshoppers and small rodents such as mice and voles (Zarn 1974, Haug and Oliphant 1990, Herriott 1989).

Like the ferruginous hawk, the burrowing owl's breeding range in Canada is becoming compressed, largely because of land use practices that include the cultivation of former grassland areas (Wedgwood 1978, Herriott 1989). The other major factor potentially acting on the reduction in numbers of burrowing owls is related to pesticide application. Recent grasshopper infestations in Saskatchewan have led to widespread application of insecticides that not only reduce the availability of food for the burrowing owl but may also result in direct mortality to the birds (James and Fox 1987, Herriott 1989, Haug and Oliphant 1990).

4.3.1 Burrowing Owl and Water Management

With regard to potential study area - related water management or water resource development activities, little direct impacts on the burrowing owl might be anticipated. Preferred breeding habitat occurs in upland areas, not in valleys where changes in reservoir elevations or creation of new reservoirs would inundate habitat. Again, like the ferruginous hawk, impacts on burrowing owls are likely to be more indirect in nature, notably the cultivation of former grassland areas.

5.0 OTHER WILDLIFE

While the study area supports a broad diversity of wildlife, limited information exists on the numbers and distribution of these species. Information of a more quantitative and site-specific nature is largely confined to species of direct economic importance (e.g., big game and game birds) or to those species for which there is strong public interest (e.g., uncommon species such as eagles or herons). Given that this study was an office-based study, exclusive reliance was made upon existing information which focused on the above-described wildlife groups. The principal sources of this information included a report by SSRBS Technical Report E.7 and critical wildlife habitat maps produced by the Province as part of the Terrestrial Wildlife Habitat inventory series. Data from this latter source was digitized into the GIS (see wildlife resources map folio) and are summarized in Table 5.

5.1 UNGULATES

Five ungulate species frequent the study area: white-tailed deer, mule deer, pronghorn antelope, elk or wapiti and moose. The amount of critical wildlife habitat for these species decreases in abundance in the same order as the species are listed in Table 5.

Preferred habitat for white-tailed deer in Saskatchewan includes a mixture of native vegetation (usually involving some dense tree cover) and cropland (Martinka 1968, Kramer 1972, Hart and Barber 1979, Stewart 1981). White-tailed deer critical habitat occurs throughout the study area although it is largely restricted to major watercourses in the southern and western portions of the basin (see wildlife map folio). In the northern portion of the basin, critical habitat for this species also occurs in upland areas where larger stands of aspen are more common. Critical habitat for this species comprises 7 percent of the study area (Table 5).

Mule deer habitat in Saskatchewan is typically composed of grassland and shrubs within a high relief setting such as that associated with river valleys and coulees (Martinka 1968, Kramer 1972, Hart and Hunt 1979, Wallmo 1981, Swenson et al. 1983). Mule deer critical habitat is closely aligned with the high relief terrain associated with the watercourses in the study area although little of this habitat occurs north of the town of Outlook (see wildlife map folio). Approximately 5 percent of the study area constitutes critical habitat for this species (Table 5).

Pronghorn antelope habitat includes broad expanses of grassland and shrub, particularly sage located within rolling to high relief terrain (Barrett 1974, Yoakum 1974, Hart and Hunt 1979, Barrett 1980, Popowski and Pyle 1984). Pronghorn antelope critical habitat also includes the watercourses of the study area but its distribution is largely restricted to the area south of the South Saskatchewan River (see wildlife map folio). Critical wildlife habitat for this species amounts to 4.0 percent of the study area (Table 5).

Elk habitat in Saskatchewan consists of mixed wood forests interspersed with grassland - meadow areas and croplands (Hunt 1981). Elk critical habitat in the study area is restricted in size and location; all of this habitat occurs in the extreme northern portion of the basin in the vicinity of Prince Albert (see wildlife map folio). Only 0.6 percent of the study area constitutes critical habitat for elk (Table 5).

Moose habitat preferences include forested areas in early-successional stages in a landscape that contains wetlands (Berg and Phillips 1974, Le Resche et al. 1974). Moose critical wildlife habitat comprises less than 0.1 percent of the study area (Table 5) and is restricted to an area along the North Saskatchewan River, east of Prince Albert (see wildlife map folio).

5.2 FURBEARERS

Black bear habitat incorporates both deciduous and mixed-wood forests, with the availability of wild berries being an important factor (Banfield 1974, Fuller and Keith 1980, Rue 1981, Savage and Savage 1981, Herrero 1985, Rogers and Allen 1987). Critical black bear habitat in the study area is restricted to the extreme northeastern portion of the basin along the South Saskatchewan River, east of Prince Albert (see wildlife map folio). Less than 0.1 percent of the study area constitutes critical habitat for this species (Table 5).

TABLE 5 **CRITICAL WILDLIFE HABITAT IN THE SOUTH SASKATCHEWAN RIVER BASIN AS DETERMINED FROM THE 1:250 000 SASKATCHEWAN PARKS AND RENEWABLE RESOURCES CRITICAL WILDLIFE HABITAT MAPS**

SPECIES	AREA (ha)	PERCENT OF TOTAL BASIN AREA
Great Blue Heron	778	0.02
Sharp-tailed Grouse	226 036	6.03
Ruffed Grouse	36 517	0.97
Spruce Grouse	642	0.06
Gray Partridge	17 738	0.47
Ring-necked Pheasant	42 192	1.13
Prairie Falcon	65 067	1.74
Golden Eagle	122 843	3.28
White-tailed deer	256 685	6.85
Mule deer	185 628	4.96
Elk	22 465	0.60
Moose	1 096	0.03
Pronghorn antelope	149 044	3.98
Beaver	2 790	0.07
Black bear	2 776	0.07

Good beaver habitat occurs in a landscape with a high density of waterbodies and where the waterbodies have stable water levels and are sufficiently deep to allow overwintering; the banks of these waterbodies should also have stable and fine-texture soils for construction of bank dens and there should also be deciduous vegetation within 200 m of the waterbodies to provide food and materials for lodge building (Allen 1983). Critical habitat for the beaver is confined to the northern portion of the basin along the South Saskatchewan River near Prince Albert (see wildlife map folio). The amount of critical habitat is limited to only 0.1 percent of the basin (Table 5).

5.3 UPLAND GAME BIRDS

The sharp-tailed grouse, ring-necked pheasant, ruffed grouse, gray partridge and spruce grouse represent the species of upland game birds in the study area in decreasing order of occurrence with respect to amounts of critical habitat (Table 5).

Preferred sharp-tailed grouse habitat includes native grassland areas, although these birds will frequent adjoining cereal croplands (Pepper 1972, Moyles 1981, Prose 1987). Critical wildlife habitat for this species occurs throughout the study area (see wildlife map folio) and comprises approximately 6 percent of the basin (Table 5).

Ring-necked pheasants prefer habitat in the form of dense woody and herbaceous vegetation which, in Saskatchewan, is often associated with watercourses and wetlands (Hart and Hunt 1980). Critical habitat for this species is largely restricted to the southern portion of the study area and along watercourses such as Swift Current Creek and the South Saskatchewan River (see wildlife map folio). Approximately 1 percent of the study area is comprised of critical habitat for the ring-necked pheasant (Table 5).

The gray (Hungarian) partridge has similar habitat requirements to the ring-necked pheasant but is perhaps even more tolerant of more intensive agriculture (Hunt 1974, Lokemoen and Kruse 1977, Hart and Barber 1979). Gray partridge occur throughout the basin but are most abundant in the south. Critical habitat for this species comprises only less than 1 percent of the basin (see wildlife map folio and Table 5).

The ruffed grouse frequents deciduous and mixed-wood forests but can also be encountered in isolated woodlots and drainages (Gullion 1970, Johnsgard 1975, Gullion 1977, Hart and Hunt 1981). Ruffed grouse numbers are subject to dramatic fluctuations, with numbers cycling in an approximately 10-year cycle (Rusch and Keith 1971, Rusch et al. 1978). Ruffed grouse critical habitat, which comprises approximately 1 percent of the basin (Table 5). occurs primarily along watercourses and in larger stands of trees in the northern portion of the basin (see wildlife map folio).

The spruce grouse is typically a resident of coniferous forests although it will frequent mixed-wood ares as well (Johnsgard 1975, Salt and Salt 1976, Godfrey 1986). Its distribution in the study area is restricted to the northern portion of the basin (see wildlife map folio) and critical habitat is limited to less than 0.1 percent of the basin (Table 5).

5.4 OTHER BIRDS

Prairie falcon habitat typically includes open grassland in close proximity to cliffs, coulees and rock outcrops which are used for nesting (Salt and Salt 1976, Call 1978, Sousa 1981). In the study area, prairie falcon critical habitat is primarily distributed along watercourses in the southern portion of the basin (see wildlife map folio). Approximately 2 percent of the basin is considered critical habitat for this species (Table 5).

The golden eagle's habitat requirements in southern Saskatchewan are similar to those of the prairie falcon (Godfrey 1986). Again this species' distribution in the study area is restricted to the southern portion of the basin (see wildlife map folio) and critical habitat involves 3 percent of the basin (Table 5).

The great blue heron nests in colonies, typically in tall trees near water (Vermeer 1973, Roney 1978, Brechtl 1981). Critical habitat for this species is distributed along watercourses throughout the basin (see wildlife map folio) but involves less than 0.1 percent of the basin (Table 5).

5.5 OTHER WILDLIFE AND WATER MANAGEMENT

Existing water resource developments will have limited impacts on these "other wildlife" resources beyond what has already occurred. For example, existing reservoirs have already inundated wildlife habitat. On the positive side, irrigation ditches and the attendant vegetation and water associated with those ditches, provides a micro-habitat for various wildlife in a often arid environment. Future water management water resource developments have some potential to affect wildlife in the study area. Habitat for these species could be directly affected by a new reservoir inundating some of that habitat. This is a site-specific issue and the magnitude of this type of impact would be dependant on the size and location of the reservoir. For example, a reservoir in the southern portion of the basin could affect mule deer, pronghorn antelope and ring-necked pheasants while one in the north could affect white-tailed deer, ruffed grouse and perhaps moose and elk.

Security is offered to wildlife populations through provincial legislation. The Critical Wildlife Habitat Protection Act is designed for the protection and management of Crown lands critical to the maintenance of wildlife populations. The Ecological Reserves Act provides a similar benefit in that it was formulated to preserve Crown lands in order to sustain a unique or representative part of the natural environment, which includes water. Both pieces of legislation outline the kinds of activities which may take place within the designated areas. Over 400 000 ha or some 11 percent of the South Saskatchewan River Basin is comprised of critical wildlife habitat.

More indirect impacts on wildlife relate to greater water availability through operational flexibility or a new source of water providing opportunities for expansion of irrigation-assisted agriculture in surrounding uplands. The concern here is for the cultivation of grassland areas, habitat upon which species such as pronghorn antelope and sharp-tailed grouse are strongly dependant. Similarly, drainage projects have the potential to degrade wetland habitat and the wildlife associated with these wetlands (Young 1989). In contrast, some expansion of cultivated acreage accompanied by the presence of shrub cover along irrigation ditches can in fact create new habitat for species such as ring-necked pheasants and gray partridge (Young et al. 1984b, c) and to a lesser extent, white-tailed deer (Strong Hall & Associates Ltd. et al. 1984).

6.0 NATURAL AND IBP AREAS

The International Biological Program (IBP) was part of the International Council of Scientific Unions, and undertook the inventory and identification of all natural areas worthy of preservation across Saskatchewan in the late 1960s and early 1970s. Natural areas are defined by Cranna and Rowe (1974) as a tract of terrain which preserves the native flora, fauna and physiographic features.

By 1973, 101 areas had been identified and accepted for formal designation as IBP sites by the IBP committee. Information regarding natural areas and designated IBP areas in the South Saskatchewan River Basin were compiled primarily from La Roi et al. (1979) and Adam (1985).

Fourteen IBP or natural areas, consisting of approximately 65 000 ha (about 1 percent) of the study area, occur within the Saskatchewan portion of the South Saskatchewan River Basin.

IBP and natural areas are not always formally declared conservation areas. Some are public or privately held lands, while others are officially protected because they fall within existing provincial parks, federal wildlife refuges or ecological reserves.

Adam (1985) conducted a review of Saskatchewan's existing IBP areas, and recommended the retention or deletion of individual areas based on current land use practices and/or the extent of human impacts. Several new natural areas were proposed at this time, some of which were to replace existing IBP areas which had been extensively impacted. In addition, changes to the boundaries (and consequently the size) of several of the areas were suggested by Adam (1985) in order to maintain the integrity of the IBP and natural areas program. The size of the IBP and natural areas in the South Saskatchewan River Basin as indicated on Table 6 refer to those proposed by Adam (1985) and may represent a modification of the original IBP area as documented by La Roi et al. (1979). The locations of these areas are also illustrated in the environmentally sensitive areas map folio.

As documented in Table 6, IBP and natural areas in the study area are listed by name, current conservation status, referenced location, size, ecoregion, ecodistrict, existing impacts, and a summary of special biological and physical features. Of the IBP and natural areas found within the South Saskatchewan River Basin, the conservation status is restricted to classes "C" and "D". In the case of the former, this represents areas with some manner of formal conservation status, such as provincial parks, federal wildlife refuges and ecological reserves. Class "D" areas are those which have no formal conservation status, usually represented by undesignated public land, leased, or private land (La Roi et al. 1979). There are currently no Class "A" or "B" IBP sites in the South Saskatchewan River Basin. Class "A" areas are those "... with formal conservation status and are recognized in the United Nations List of Natural Parks and Equivalent Reserves" (La Roi et al. 1979:4). Class "B" areas are those which were considered for Class "A" status but were rejected due to inadequate protection or features (op.cit.).

Ecoregions are defined as an area "... characterized by distinctive ecological responses to climate as expressed by the development of vegetation, soils, water, fauna, etc." (Environmental Conservation Service Task Force 1981). Each ecoregion is characterized by a broad vegetation formation, for example, grasslands or parklands. Provincially, Saskatchewan is comprised of six such zones, three of which (grassland, parkland and southern boreal) are represented in the study area (Adam 1985). Within each ecoregion are a varying number of ecodistricts, that is an area "... characterized by distinctive assemblages of relief, geology, geomorphology, vegetation, soils, water and fauna." (Environmental Conservation Service Task Force 1981). For example, the aspen parkland ecoregion is comprised of the aspen - burr oak and aspen grove ecodistricts. Ecoregions and ecodistricts in this report follow those defined by Harris et al. (1983).

Several of the areas delineated feature characteristics of exceptional interest, as listed on Table 6. Several of the indicated areas contain critical wildlife habitat for a variety of species, including the South Saskatchewan River Loop, Red Deer Forks, Yakowan, and Matador grassland/Swift Current Creek areas. The Matador grassland/Swift Current Creek area is also noted for it's extensive coulee complexes, and significant nesting areas for golden eagle, prairie falcon, merlin and ferruginous hawk. Parks Canada has identified this area as one of only five natural sites of Canadian Significance in Saskatchewan (Adam 1985). The Yakowan natural area is also a natural site of Canadian significance within the study area. The South Saskatchewan River Loop, Heart's Hill, Yakowan, Matador Moraine, Dundurn Forest, and Nisbet Forest have all been identified as possessing exceptional floral communities ranging from rare plant species, species found at the extreme edge of their range, or large blocks of relatively undisturbed native flora.

Adam (1985) further recommended the deletion of five present IBP Areas from the provincial list due to the extent and severity of impacts. These proposed delisted Areas include the Duck Lake - Batoche, Alsask - Mantario, Red Deer Forks, Lancer Moraine, and Indi IBP Areas.

TABLE 6 NATURAL AND IBP AREAS WITHIN THE SOUTH SASKATCHEWAN RIVER BASIN

NAME	CONSERVATION STATUS*	LOCATION	SIZE (ha)	ECOREGION	ECODISTRICT	SPECIAL BIOLOGICAL FEATURES	SPECIAL PHYSICAL FEATURES	EXISTING IMPACTS	OTHER COMMENTS
South Saskatchewan River Loop	D	31 km W of Leader	1 300	Grassland	Sandhills Complex	Ord's kangaroo rat, prairie rattle-snake, 4 species of rare plants	active and stabilized sand dunes in area	grazing	Historically significant area. Critical Wildlife Habitat for - mule deer - Golden Eagles - Sharp-tailed Grouse
Hearts Hill	D	58 km W of Kerrobert	6 281	Grassland	Mixed Prairie	large block of native prairie	numerous sloughs and Kettle Lakes	drainage, grazing, haying, fireguards, vehicle trails, road	n.a.
Alsask - Mantario Hills	D	Near Alsask and Mantario	16 123	Grassland	Mixed Prairie	n.a.	high landform diversity when coupled with Mantario moraine area	cultivation, grazing, hunting, human habitation, roads, railroad line	Adam (1985) recommended delisting from IBP inventory
Red Deer Forks	D	24 km W of Leader	1425	Grassland	Mixed Prairie	n.a.	n.a.	grazing, roads and trails, railroad line	Adam (1985) recommended delisting from IBP inventory. Historically significant area. Critical wildlife Habitat for - mule deer, - Golden Eagles
Cabri Lake	D	58 km SW of Kindersley	12 000	Grassland	Mixed Prairie	n.a.	n.a.	cultivation, grazing, hunting, vehicle trails	significant historical (archaeological) resources in area
Yakowan (Great Sand Hills)	D	23 km NE of Fox Valley	9 600	Grassland	Sandhill Complex	Ord's kangaroo rat, three rare plant species	largest area of sand, and highest dunes in southern Saskatchewan	petroleum and natural gas leases, grazing, hunting, roads and trails	Natural Site of Canadian Significance, Critical Wildlife Habitat for - mule deer - Sharp-tailed Grouse
Lancer Moraine	D	5 km E of Lancer	1 263	Grassland	Mixed Prairie	n.a.	thrust or end moraine	drainage, grazing, gravel pit, roads and trails	Adam (1985) recommended delisting from IBP inventory

TABLE 6 NATURAL AND IBP AREAS WITHIN THE SOUTH SASKATCHEWAN RIVER BASIN

NAME	CONSERVATION STATUS*	LOCATION	SIZE (ha)	ECOREGION	ECODISTRICT	SPECIAL BIOLOGICAL FEATURES	SPECIAL PHYSICAL FEATURES	EXISTING IMPACTS	OTHER COMMENTS
Matador Morain	D	61 km N of Swift Current	3 110	Grassland	Mixed Prairie	relatively undisturbed moraine grassland	extensive ridged end-moraine area	drainage, hunting, grazing vehicle trails	n.a.
Matador Grassland/ Swift Current Creek	C/D	35 km N of Swift Current	9 096	Grassland	Mixed Prairie	significant nesting area for Prairie Falcon, Golden Eagle, Ferruginous Hawk, Merlin	extensive and spectacular coulees in Natural Area	grazing, hunting, minimal cultivation, research station with associated human impacts	Natural Site of Canadian Significance, Critical Wildlife habitat for - white-tailed deer - mule deer - Prairie Falcon - Golden Eagle
Beaver Creek	D	16 km S of Saskatoon	81	Grassland	Mixed Prairie	n.a.	n.a.	walking trails	used as a public education facility
Dundurn Forest	D	34 km S of Saskatoon	2 072	Grassland	Mixed Prairie	uncommon and rare boreal flora present	sand dune complexes	military exercise area	n.a.
Indi Lake	D	50 km S of Saskatoon	680	Grassland	Mixed Prairie	minor waterfowl production, high priority waterfowl moulting habitat	n.a.	n.a.	Adam (1985) recommended delisting from IBP inventory
Duck Lake - Batoche	D	W of Batoche	1 477	Parkland	Aspen Grove	n.a.	n.a.	cultivation, grazing, hunting, vehicle trails	historically significant site Adams (1988) recommended delisting from IBP inventory
Nisbet Forest	C	14 km NE of Duck Lake	486	Southern Boreal	Mixedwood - Parkland	high floral diversity, boreal forest bogs near southern limit of range in Saskatchewan	n.a.	grazing, gravel pits, snowmobile cross-country ski and horse trails present	n.a.

n.a. = not applicable
* C = areas with formal conservation status (e.g., ecological reserves, provincial parks, federal wildlife refuges)
D = areas with no formal conservation status

6.1 NATURAL AND IBP AREAS AND WATER MANAGEMENT

Water management or water resource developments have considerable potential to affect natural and environmentally sensitive areas. For example, they could be flooded by a new reservoir or affected by changes in the way existing water control structures are operated. Wetland areas could be drained, or grassland areas placed under cultivation to take advantage of irrigation water.

7.0 FISHERIES

Saskatchewan's fisheries sector makes an important contribution to the provincial economy. Freshwater sport fishing is one of the province's major tourist draws, with some 230 000 anglers in Saskatchewan pursuing the activity. Commercial fisheries also exist in the province, with the fishery based at Lake Diefenbaker producing a whitefish harvest of approximately 91 000 kilograms annually.

There are a large number of variables which may affect fisheries resources in a managed river system, such as the South Saskatchewan River in Saskatchewan. Following is a review of these variables, together with a summary of information which is available for the study area.

7.1 ASSESSMENT OF THE RESOURCE

The South Saskatchewan River is impounded within the study area at Lake Diefenbaker, while a number of dams are situated on the major headwater tributaries of the river in Alberta (e.g., Bassano, Bearspaw, and Ghost dams on the Bow River, Dickson Dam on the Red Deer River, and the nearly completed Oldman River Dam). The result of impounding a free-flowing river is the initiation of a sequence of changes in the downstream channel and the associated riparian habitats (Petts 1984). The extent and severity of such changes are predictable in only general terms, as the effects of impoundment are a consequence of complex interactions between the components of the lotic system.

The data base which is available to specifically address the fisheries resources of the South Saskatchewan River in the study area is limited. The most comprehensive survey of the river in the study area was conducted by Reed (1962), prior to the construction of the Gardiner Dam and many of the dams in the river headwaters, and is thus of limited value in assessing present streamflow requirements for fishes.

The study documented in SSRBS Technical Report D.8 was commissioned in recognition of this data deficiency. This study documented the presence of some 27 species (Table 7) at five sampling stations in the South Saskatchewan River in Saskatchewan, two reservoirs in the Swift Current Creek drainage basin and five reservoirs in the Saskatoon Southeast Water Supply (SSEWS) system.

Highest yields of fish were obtained from the reservoirs of the SSEWS system. The greatest diversity of species was caught downstream of Gardiner Dam. This included species typical of lakes such as lake whitefish and ciscoes, and also introduced species like rainbow trout and brook trout, in the unique habitat created by the cold clean water discharged from Lake Diefenbaker.

The fisheries survey (SSRBS Technical Report D.8) also determined that distribution of fish in the South Saskatchewan River is related to river use. The least suitable habitat for fish is the stretch of river upstream of Saskatoon to Lake Diefenbaker. The modified habitat downstream of Saskatoon, characterized by vegetation and organic substrate, is more suited for pike, walleye and several species of suckers. The conditions upstream of Lake Diefenbaker are most typical of river conditions prior to 1960, when goldeye, sauger, walleye and sturgeon were the predominate species.

The economically important sportfish species present in the study area, their distribution in the South Saskatchewan River Basin, and the timing of important life stage events are summarized in general terms in Table 8.

7.1.1 Fish Species

The following presents a brief summary of the main findings of the fishery survey (SSRBS Technical Report D.8).

Walleye were the most frequently encountered gamefish in the study area during the 1988 survey. This species is well distributed throughout the waters and reservoirs of the South Saskatchewan River, Swift Current Creek and the SSEWS system.

Goldeye were the second most abundant gamefish in the South Saskatchewan River, but were not found in the reservoirs or the Swift Current Creek system. Survey data indicates that while goldeye can be found in most areas of the river, their populations have increased upstream of Lake Diefenbaker.

TABLE 7 FISH SPECIES COLLECTED BY GILLNETTING AND SEINING IN THE SOUTH SASKATCHEWAN RIVER SYSTEM IN 1988 (SSRBS TECHNICAL REPORT D.8)

COMMON NAME	SCIENTIFIC NAME
Lake sturgeon[a]	*Acipenser fulvescens*
Quillback	*Carpiodes cyprinus*
Longnose sucker	*Catostomus catostomus*
Common white sucker	*Catostomus commersoni*
Cisco, tullibee	*Coregonus artedii*
Lake whitefish	*Coregonus clupeaformis*
Spoonhead sculpin	*Cottus ricei*
Lake chub	*Couesius plumbeus*
Northern pike	*Esox lucius*
Iowa darter	*Etheostoma exile*
Brook stickleback	*Eucalia inconstans*
Goldeye	*Hiodon alosoides*
Mooneye	*Hiodon tergisus*
Flathead chub	*Hybopsis gracilis*
Burbot, ling, freshwater cod	*Lota lota*
Shorthead redhorse	*Moxostoma marolepidotum*
Emerald shiner	*Notropis atherinoides*
River shiner	*Notropis blennius*
Spottail shiner	*Notropis hudsonius*
Yellow perch	*Perca flavescens*
Trout-perch	*Percopsis omiscomaycus*
Fathead minnow	*Pimephales promelas*
Longnose dace	*Rhinichthys cataractae*
Rainbow trout	*Oncorhynchus mykiss*
Brook trout	*Salvelinus fontinalis*
Sauger	*Stizostedion canadense*
Walleye, pickerel	*Stizostedion vitreum vitreum*

a This species is considered "threatened" by the American Fisheries Society

TABLE 8 **SPORTFISH PRESENT, LIFE HISTORY REQUIREMENTS, AND DISTRIBUTION WITHIN THE SOUTH SASKATCHEWAN RIVER BASIN**

SPORTFISH	TIMING OF SPECIES - LIFE STAGES PRESENT[1]				HABITAT REQUIREMENTS				DISTRIBUTION[2]
	FRY	JUVENILE	ADULT	SPAWNING	FRY	JUVENILE	ADULT	SPAWNING	
Lake sturgeon (*Acipenser fulvescens*)	Late July to December	January to December	January to December	Early May to late June	?	Deep, slow moving pools and runs	Deep, slow moving pools and runs	Fast flowing rapids	Likely upstream of Lake Diefenbaker, but spawning primarily in Alberta
Lake whitefish (*Coregonus clupeaformis*)	Late March to December	January to December	January to December	Late October to mid-November	Pelagic, upper 20 m (lakes), shallows (rivers)	Upper 20 m (lakes), slow flowing pools and backwaters (rivers)	Upper 20 m (lakes) slow flowing pools and backwaters (rivers)	Fast flowing riffles	Most common in Gardiner Dam and tailwater. They are distributed throughout the study area
Northern pike (*Esox lucius*)	Late June to December	January to December	January to December	Late April to early May	Shallow water with dense vegetation	Backwaters and quiet pools with emergent/ submergent vegetation	Backwaters and quiet pools with emergent/ submergent vegetation	Dense mat of flooded vegetation	Distributed throughout the study area, most common at Fenton ferry in the South Saskatchewan River and in the Swift Current Creek system
Goldeye (*Hiodon alosoides*)	July to December	January to December	January to December	Late May to mid-June	?	Edges of eddys and faster water	Edges of eddys and faster water	?	Distributed throughout the study area, most common at Fenton ferry in the South Saskatchewan River, and in the Swift Current Creek system

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TABLE 8 SPORTFISH PRESENT, LIFE HISTORY REQUIREMENTS, AND DISTRIBUTION WITHIN THE SOUTH SASKATCHEWAN RIVER BASIN

SPORTFISH	TIMING OF SPECIES - LIFE STAGES PRESENT[1]				HABITAT REQUIREMENTS				DISTRIBUTION[2]
	FRY	JUVENILE	ADULT	SPAWNING	FRY	JUVENILE	ADULT	SPAWNING	
Mooneye (*Hiodon tergisus*)	July to December	January to December	January to December	Late May to mid-June	?	Edges of eddys and faster water	Edges of eddys and faster water	?	Distributed throughout the study area. Not found in the Swift Current Creek system
Yellow perch (*Perca flavescens*)	Late June to December	January to December	January to December	Early May to Early June	Pelagic, open water	Littoral areas with abundant vegetation	Upper 10 m of the water column	Submerged dense mat of vegetation	Present in all the reservoirs in the study area except for Blackstrap Reservoir
Walleye (*Stizostedion vitreum vitreum*)	July to December	January to December	January to December	End of April to mid-May	Shallow, quiet waters	Slow flowing runs and pools	Deep, slow flowing runs and pools.	Riffles and fast, shallow runs with sand, gravel/ cobble	Distributed throughout the study area. Most common in Lake Diefenbaker and Bradwell, Zelma, Blackstrap and Dellwood reservoirs
Sauger (*Stizostedion canadense*)	July to December	January to December	January to December	End of April to mid-May	Turbid, shallow quiet waters	Turbid, slow flowing runs and pools	Deep, turbid, slow flowing runs and pools	Riffles and fast, shallow runs with sand, gravel and/or cobble	Distributed throughout the South Saskatchewan River system. Most common South Saskatchewan River at Estuary ferry.

Note: Rainbow trout (*Onchorhyncus mykiss*) and brook trout (*Salvelinus fontinalis*) have been stocked in Lake Diefenbaker.
2 The time of spawning and fry life stages is based on the presence of appropriate temperature. The time described represents the range at which one might expect to see these lifestages in the study area.
3 Data from SSRBS Technical Report D.8

Northern pike were taken from all sampling locations, indicating a widespread distribution. Sauger, a close relative of walleye, was encountered only in the South Saskatchewan River. That portion of the river upstream of Lake Diefenbaker provided the best habitat for sauger in the study.

Lake whitefish have a restricted distribution in the South Saskatchewan River, but are common in Lake Diefenbaker. The species was also found to be relatively abundant in the SSEWS system. These whitefish are believed to have originated in Lake Diefenbaker and adapted to the static conditions provided by the reservoirs.

Burbot had a distribution restricted to just below Gardiner Dam in 1988, in contrast to the wide distribution in the South Saskatchewan River recorded during a survey undertaken in 1957 and 1958.

Yellow perch have never been abundant in the South Saskatchewan River. Varying populations of this species are found in some of the SSEWS system reservoirs and in Duncairn Reservoir on Swift Current Creek.

7.2 FISHERIES AND WATER MANAGEMENT

Petts (1984) identified a number of biotic and abiotic effects of river impoundment, which result in primary impacts on the habitats provided by the riverine environment (Table 9). The relationships between these variables, and the primary impacts on the riverine environment may be summarized as follows. The creation of reservoirs results in increased evaporation, and thus a reduction in annual runoff. The storage of water for subsequent release obviously alters the natural flow pattern. Chemical and thermal changes in downstream water quality are experienced, and are influenced by the level at which water is discharged from the reservoir. Annual plankton loads in the downstream riverine environment may be increased by 150 to 200 times. The release of sediment-free water can cause channel-bed degradation and accelerated erosion rates, and an increase in the average size of substrate particles. Conversely, flow regulation may induce channel aggradation or build-up below tributary streams which are significant sources of sediment.

The regular release of clear-water discharges onto stable substrates may cause an increase in the growth of periphyton and macrophytes, on a year-round basis. Changes may be experienced in the vegetative community on the floodplain, with a reduction in diversity, density and productivity as the soils dry out. A dense, rich but narrow riparian vegetation zone may develop, depending on the degree of regulation, which is often dominated by species such as willows. Changes in water quality and quantity, channel morphometry and substrate particle sizes result in changes in the species composition and abundance of benthic invertebrates.

The native fish species composition may change, and some species may be eliminated below reservoirs because of the changes which occur in their environment. Such changes include alteration or loss of spawning areas, blockages which preclude access to spawning areas and reduced summer temperatures. The altered hydrologic regime can cause changes in channel morphology, water quality characteristics, and primary and secondary productivity, all of which are important to the well-being of the fishery resource, for up to 100 km below some dams (Petts 1984).

One study area example of a fish species which has been affected by the creation of Lake Diefenbaker is the goldeye. Information contained in SSRBS Technical Report D.8 suggested that obstructions such as the Gardiner Dam and the weir at Saskatoon may interfere with the ability of goldeye to find suitable spawning sites, thus resulting in few of this species in the lower reaches of the river.

The biotic and abiotic environments upstream of Lake Diefenbaker are likely still in the process of adjusting to the effects of the Dickson Dam on the Red Deer River, which commenced operation in the mid-1980s. Changes in this region of the study area may also be experienced as a result of the Oldman River Dam, which will be at least partially filled in 1991. Downstream of Gardiner Dam, the aquatic environments have likely reached an equilibrium in response to modifications in the flow volumes and patterns which resulted from the creation of Lake Diefenbaker approximately 25 years ago.

Following is a discussion of the various disciplines which should be considered from the fisheries perspective to assess the effects of water management on the aquatic environments in the South Saskatchewan River Basin. In general, insufficient information is available to identify the effects of water management on the biotic environments either upstream or downstream of Lake Diefenbaker, which therefore precludes the identification of potential impacts on the aquatic resources which may result from new developments or water management strategies within the study area.

TABLE 9	SUMMARY OF IMPACTS RESULTING FROM RIVER IMPOUNDMENT [MODIFIED FROM PETTS (1984)]
BIOTIC EFFECTS	**ABIOTIC EFFECTS**
PRIMARY PRODUCTIVITY	Reduced turbidity
Increased light penetration	Channel erosion
Elimination of ice cover	- tributary rejuvenation
Increased substrate stability	- increased channel depth
	- coarser sediments
INVERTEBRATES	Increased evaporative losses
Loss of thermal cues	Elevated winter temperatures
Substrate sedimentation	Reduced dissolved oxygen concentrations
Stranding and enhanced drift	Increased pollution and salinity
	Channel aggradation
FISH	Flushing of fine sediments
Obstruction to migration	Floodplain erosion
Delayed migration	Cessation of silt enrichment
Increased plankton loads	Encroachment of terrestrial vegetation
Elimination of warmwater species	Reduced wetlands
Gas supersaturation	Floodplain stabilization
Deterioration of spawning gravels	
Loss of flood-season spawning habitat	

The first issue which must be addressed, for a variety of reasons, is the hydrology of the impounded river. This issue is extremely important, as it is the ultimate limitation facing water management opportunities. This fundamental characteristic, together with the water management objective(s) (e.g. flood control, hydro-electric power generation, stabilized runoff pattern or irrigation), dictate management strategy. Project designs and operating strategies are the primary determinants of potential impacts on the downstream riverine environment, and the starting point for instream flow needs considerations. Within the study area, the natural flows of the South Saskatchewan River are modified due to consumptive uses of river water in Alberta, as well as existing water management in the Saskatchewan component of the basin. As previously noted, water deliveries to the Saskatchewan border continue to be altered due to water management activities in the Province of Alberta.

River water quality is largely dictated by the climate and geological characteristics of the drainage basin (Petts 1984). The impoundment of river water in reservoirs causes physical, chemical and biological changes within the stored water, which defines one component of the macrohabitat in the downstream riverine environment. Irrigation return flows and waste water assimilation also affects the quality of the environment in which the fishery resource must survive. These characteristics are generally well known within the study area, as a result of monitoring activities by regulatory agencies.

Water quality aspects must be considered when evaluating the physical and chemical processes which have been experienced, and may be expected in altering the management strategy of the basin. Through the use of mathematical models, and predictions of the flow and quality of reservoir releases, the basin manager can be provided with estimates of water quality in the regulated river, and the distance required before that quality returns to an approximately natural conditions. The predicted effects of water quality alterations may then be included in the multidisciplinary analysis of the environmental consequences of regulating the riverine environment.

Hydrological predictions regarding the effects of altered river flows on the existing channel characteristics are also required. Bovee (1982) noted that instream flow investigators are faced with one of two choices in terms of channel dynamics: determine a flow regime that would prevent channel change, or, predict the new channel shape, should a channel change be inevitable. The latter choice is obviously more risky, and hence less desirable.

Two concepts are involved in addressing channel maintenance issues from the biological perspective. The first is the question of how the channel may change in the regulated stream. A primary requirement from a fisheries perspective is the determination of the quality of microhabitats which will exist in the regulated river channel. If structural changes in the river channel are predicted, a definition of these changes is required to assess the effects of a proposed flow regime, or to provide estimates of the amount of flow required to provide habitat of a certain quality in the altered channel. It is much easier to examine the channel characteristics which exist, and evaluate the effects of river flow on those habitat values. Examples of changes in river morphology are present downstream of Gardiner Dam. Upstream of Lake Diefenbaker, the river morphology has not likely undergone any significant changes as a result of water management in Alberta, because until very recently, both the Red Deer and Oldman rivers have been free-flowing. However, the creation of the Dickson Dam on the Red Deer River in the mid-1980s, and the commissioning of the Oldman River Dam in 1991 may well result in a change in river morphology in this upstream river reach.

The second issue which is important to the biologist in terms of channel maintenance is the concept of a flushing flow. A flushing flow is defined as the flow which is required to flush or remove the fine sediments from the stream gravels. The purpose of such a flow is to maintain the quality of highly productive and important habitats such as spawning areas, or riffles where benthic invertebrate productivity is the highest. Thus the concept of maintaining existing channel geometry, and protection of that channel from the undesirable consequences of sedimentation, are interrelated in terms of maintaining desired channel characteristics. The river reaches downstream of Gardiner Dam are exhibiting characteristics of a regulated river which are not experiencing appropriate flushing flows.

Another discipline-specific issue which must be considered in assessing instream flow issues in water management is the effect of flow regulation on vegetation. A wide array of issues are involved in this component of the analysis, ranging from the importance of primary production by the aquatic flora (periphyton through to macrophytes) through to the significance of riparian vegetation for ecosystem integrity.

The effects of flow regulation on aquatic plants must first be considered. The majority of aquatic plants are not adapted to lotic or running-water systems, as they lack the adaptations required to resist detachment or damage which result from increases in water velocity, or recover from the significant losses of attached flora which occur as a result of substrate movement during periods of high flow (Petts 1984). Flood frequency and duration often define the species composition of the instream flora, as the frequency of floods which may be tolerated by any particular species is dependent at least in part upon the growth rate of the species after the damage has occurred.

Macrophytes in lotic systems tend to establish their own microhabitats, by trapping the organic and inorganic material which is transported by the river, as well as organic debris from death of their own parts, creating their own enriched sediment.

This microhabitat is conducive to the continued growth of the macrophytes. These aquatic plants contribute significantly to primary production in the river or stream, as well as providing a substrate for the development of periphyton and invertebrates (Welch 1980), and cover for certain life stages of fish, thus providing a very positive benefit to the river ecosystem.

Flow regulation may be conducive to the development of aquatic macrophytes due to the increase in water clarity and thus light penetration downstream of a reservoir, the stable flow-pattern which often occurs, the creation of an ice-free zone, the reduction in flows which cause substrate disturbance, and the deposition of fine sediment particles downstream of tributaries or effluent sources (Petts 1984). The result may be extensive weed growth, which may cause dissolved oxygen problems, a competition for space with other biota in the river, clogged water supply intakes, and a significant reduction in the aesthetics and recreational suitability of the watercourse. When such conditions present themselves, as is apparent in the river mainstem downstream of Saskatoon, the macrophytes are obviously no longer a potential benefit to the aquatic ecosystem.

Attached algae are also an important component of the aquatic flora, that tend to dominate the fast-flowing, turbulent, clear headwaters of free-flowing rivers, particularly under the conditions provided by stable, mid-summer flows (Petts 1984). The algae tend to decrease in abundance in downstream areas of the free-flowing river because of reduced light penetration, higher suspended sediment loads, increased concentrations of dissolved organic matter and increased water depths.

Reservoir development can result in the creation of characteristics in reservoir releases that mimic headwater conditions, which in combination with stable flows, can be very conducive to the extensive and rapid growth of algae below the reservoir. Attached algae can provide an important microhabitat for the growth of invertebrates, and in fact certain kinds of algae have been reported to be an important food for trout (Petts 1984). However, extensive algal beds are undesirable for a variety of reasons, such as causing the potential for the development of undesirable taste and odour in the water, dissolved oxygen depletion which occurs during photosynthesis and as a result of decay, intragravel flow can be reduced, water intakes can become clogged, and fishing, boating and water-contact sports can be restricted (Petts 1984). It was reported in SSRBS Technical Report that a high incidence of both macrophyte and algal growth at Clarkboro and Hague ferries had occurred in 1988.

The instream flow assessment team must therefore determine the likelihood for development of, or document excessive macrophyte or algal beds in the regulated river, define the extent of any such problem, and develop measures to preclude or minimize the occurrence of such a problem.

The third aspect of vegetation associations which must be considered in assessing instream flow needs in a regulated river is that of the riparian community. The vegetation which grows along a free-flowing river, and is dependent upon the stream water for survival is very important to fish and the maintenance of aquatic habitats (Risser and Harris 1989). Riparian vegetation provides water temperature regulation, assists in maintaining water quality, and may be critical to the maintenance of aquatic community structure and productivity. Streamside vegetation and the associated woody debris stabilize stream channels and floodplains, trap sediments and store nutrients, and can affect the magnitude and duration of floods. Riparian zones are also typically the focal point for recreation, as well as other potentially detrimental activities such as cattle grazing.

Although riparian vegetation is important in the maintenance of aquatic habitats, regular periods of high discharge are required to preclude the encroachment of terrestrial vegetation into the river channel. Examples of encroachment by riparian vegetation is apparent in the South Saskatchewan River in Saskatoon, where sand bars have developed and have become permanent islands, which have subsequently been colonized by willows.

The extreme variability in riparian systems, both between streams and within reaches of the same stream, complicates description and analysis of this feature of the aquatic ecosystem (Risser and Harris 1989). Due to the diversity of physical characteristics which regulate the growth of streamside vegetation, and the degree to which these physical characteristics may change within a very short distance along the stream, the prediction of impacts on riparian vegetation as a result of flow regulation is difficult.

The stream benthic invertebrate community is also unquestionably important in terms of the total functioning of the stream ecosystem (Ward 1976). The macroinvertebrates which provide the food base for many of the stream fishes are adapted to a particular set of conditions which prevail in a free-flowing river. Patterns of flow, temperature variation, and in particular substrate particle-sizes and stability are the dominant factors controlling macroinvertebrate distributions (Ward and Stanford 1979).

The life cycles of many riverine invertebrate species have evolved to coincide with the seasonal variations in discharge, while many of the life-cycle stages such as hatching, growth and emergence are dependent on the thermal cues provided by the river (Petts 1984). Dam construction typically results in changes to the downstream flow regime, water quality, as well as the channel morphology, all of which dictate the species composition and relative abundance of the benthic invertebrate population in the river.

The most common response by the benthic invertebrate community to river regulation is a reduction in species diversity, and often an increase in the overall abundance of organisms (Stanford and Ward 1979). This consequence is typically the result of creating uniform habitat conditions in the regulated river. The species which are suited to the particular set of relatively uniform conditions in the regulated river do very well, as indicated by the increase in the overall abundance of organisms. The remainder of the species assemblage which find these conditions intolerable is lost, however, as reflected by the reduction in species diversity.

The changes in the benthic invertebrate community which may be anticipated below a reservoir relate to the pattern of reservoir releases, the chemical, physical and biological quality of the released water, the changes to channel morphometry, substrate composition and stability, as well as the distribution of aquatic plants (Petts 1984).

It was determined in SSRBS Technical Report D.8 that the distribution of bottom fauna in the South Saskatchewan River is uneven. Benthic samples were collected in 1988 on four occasions from each of five stations in the approximately 700 km of the South Saskatchewan River in Saskatchewan. Study results indicated the soft, oozy substrates at the sampling stations yielded the anticipated predominance of midge larvae (Chironomidae) and sludge worms (Oligochaeta), which were more productive than rocky bottom areas which supported caddisflies (Trichoptera) and mayflies (Ephemeroptera). It was further reported that benthic productivity increased in downstream areas on the river, and speculated that the low standing crop of invertebrates in the region downstream of Gardiner Dam was related to the effects of spring run-off and sudden releases of water from Lake Diefenbaker.

In addition to the study of the South Saskatchewan River mainstem, the fisheries study documented in SSRBS Technical Report D.8 also examined the Swift Current Creek Basin (including Duncairn and Swift Current reservoirs), and the six reservoirs of the Saskatoon Southeast Water Supply system (Broderick, Brightwater, Blackstrap, Bradwell, Zelma and Dellwood reservoirs). In general, these reservoirs had a higher standing crop of benthic invertebrates than the river mainstem.

While the efforts expended in the 1988 investigation are admirable, they cannot be considered more than an indication of benthic productivity in such a large study area. Data of this nature are of limited use in developing reach-specific instream flow recommendations for protection of the aquatic resource.

Initial efforts to address fisheries values in regulated rivers played a large role in expanding the scope of instream flow investigations, as the health of the fishery is so strongly related to the ecological integrity of the entire aquatic ecosystem. A review was recently conducted on 81 dam projects in the Pacific Northwest (Burt and Mundie 1986), which provides a summary of potential conflicts between water management and fisheries issues, and an indication of the scope of the issue which must be addressed in considering water management within a river basin.

Due to the economic value of salmonoid populations, Burt and Mundie (1986) reported that most flow regulation projects in the Pacific Northwest are undertaken with at least some consideration for the protection of fish. Their review revealed, however, that the flow regulation projects had a poor record of success in preserving natural salmonoid stocks. In the 63 cases where sufficient information was available to reach a conclusion, 76 percent resulted in a decrease in salmonoids following flow regulation.

The most frequent causes of fish stock decline were identified as the removal of large volumes of water, such that the overall volume available for fish was reduced, and the alteration of the natural seasonal pattern of flow, resulting in reduced volumes during periods which were critical to the fish life stages. In case-histories where improvements in fish populations were reported, the main factors identified for these successes were an increase in mean annual flow, an increase in monthly flows during periods when these flows were limiting to the fisheries resource, or, no changes in post-project flows.

The second most frequent cause of declines in fish stocks below dams was the blockage of adult migrations to habitats above these water control structures (Burt and Mundie 1986). In many cases, no fishways were provided at the dams, and no attempts were made to truck fish upstream. As the majority of the fish populations under study in the Pacific Northwest were salmon, which return to their natal stream for reproduction, this factor caused the extinction of some runs. In other cases, attempts were made to compensate for losses of natural fish through artificial propagation.

The third most frequent cause of reduced salmonoid productivity was a deterioration in the quality and quantity of habitat as a result of the loss of the freshet. A major short-coming of many instream flow studies which were reviewed was emphasis on minimum flow requirements, with insufficient regard for the rejuvenating effects of peak flows in the systems. Significant flow reductions during the freshet have been identified as causing an increase in fines in spawning gravels, less development of pools and undercut banks, and vegetation encroachment, all of which result in a deterioration of habitat quality. For those case-histories where fish stocks improved, or did not decline, a reduction in habitat quality was typically not a problem, as flushing was provided by increased or relatively unchanged post-project flows.

A further cause of decreased fish stocks was identified as rapidly fluctuating flows. Typical consequences of such water management activities were stranding of juveniles, reduction in benthic invertebrate populations, and scouring of habitats.

Emphasis was placed on the evaluation of post-project predictions in the review conducted by Burt and Mundie (1986). In general, these authors found that documentation of predicted effects was lacking, and follow-up studies were not designed to test predictions. Only two exceptions were found in the review of the 81 projects, both of which involved predictions of improved natural salmonoid stocks. In one case, the population was found to improve; in the other, the fish stocks actually declined.

Burt and Mundie (1986) also identified the fact that the predictive success of instream flow methods for determining minimum protection flows for fish has not yet been established by follow-up studies.

Significant improvements have been made in addressing the instream flow requirements for fishes in the last decade. The most promising method which has been employed is the instream flow incremental methodology, which involves the use of sophisticated computer models to compare predicted microhabitat conditions in the regulated river with the habitat preferences of fishes that are present in the system (Bovee 1982). A key component of such a procedure is, however, recognition of the fact that this type of analysis is only addressing microhabitats, or how depths and velocities change with river flow, and how suitable these microhabitats are for use by the fish fauna. The prediction and evaluation of macrohabitats which are present in the regulated river are equally as important. For example, even if an ideal assemblage of depths and velocities is provided for the fish, but the water quality is unsuitable, the fish fauna will not be able to take advantage of the microhabitats which are present.

Based on the available aquatic data for the study area in Saskatchewan, it is inappropriate to infer that knowledgeable water management decisions may be made regarding the protection or enhancement of the fisheries resources in the basin. Therefore, the development of instream flow requirements for fish in the study area has not been conducted on the basis of the effects of discharge on the abiotic or biotic variables which dictate the quality or quantity of fish habitat. An effort has been made to relate habitat suitability and flow rates through discussions with individuals knowledgeable of the fisheries resource, and through the partial application of one of the original (Montana) discharge-based method for determining instream flow needs for fishes (SSRBS Technical Report E.7).

Although the discharge-based methods do not consider the effects of flow on habitat availability, such methods are useful in a general scoping of the likely streamflow requirements for protection of the aquatic resource. The Montana method employed in the previous study appears to have been applied to recorded river flows in Saskatchewan. The discharge-based techniques must be based on natural flow in the river, as opposed to the flow which has historically been experienced if significant consumptive use of the water, or alteration in flow patterns has historically taken place. It is inappropriate to provide an estimate of instream flow requirements on the basis of what is left in the watercourse after other consumptive uses have been met. This caution is particularly relevant for watercourses such as the South Saskatchewan River, given that there is considerable consumptive use and the river is high regulated both upstream of and within the study area.

Fisheries management objectives have been developed for the majority of the reservoirs within the study area, as evidenced by the occasional stocking of species such as walleye and biological investigations of some of these waterbodies. The majority of the fishes in the reservoirs within the basin in Saskatchewan are, however, a result of introductions through the canal systems. With the exception of Lake Diefenbaker, the only stocking program carried out on the river mainstem appears to have been the experimental introductions of brook trout (1987) and rainbow trout (1988) into the coldwater habitat which exists below Gardiner Dam (SSRBS Technical Report D.8). Fisheries management objectives for the mainstem river have not, apparently, been formalized.

Prior to any decisions regarding water management within the study area, a detailed investigation of the biotic and abiotic variables outlined in the preceding discussion is required, if any such decision is to be made with the intention of protecting the fisheries resources of the basin.

8.0 HERITAGE RESOURCES

8.1 REVIEW OF RESOURCES

Despite the importance of the study area from a heritage resources point of view, relatively little professional investigation within the study area has been conducted. Most archaeological excavations have occurred around the Saskatoon area, although a few important excavated sites are scattered across the southern portion of the study area. This paucity of systematic surveys of heritage resources suggests that many more important heritage sites will be discovered in the years to come.

SSRBS Technical Report E.16 identified where heritage sites are reasonably expected to occur within the study area, and to what extent they may be adversely affected by future water resource developments. To this end, archaeological and palaeontological vertebrate resources sensitivity zones were defined, plotted and mapped.

The number of heritage sites in each Borden Block location in the Saskatchewan portion of the South Saskatchewan River Basin, have been identified in the accompanying heritage resources map folio. The Borden Block is a 10 minute latitude by 10 minute longitude grid used in Canada exclusively for inventorying archaeological resources. The heritage resources study was designed to ensure thorough consideration of heritage sites in the planning and evaluation of proposed water management and development practices.

8.1.1 Archaeological Sites

The study documented in SSRBS Technical Report E.16 entailed a thorough review of pertinent background information, including the paleocultural sequence for southern Saskatchewan, the existing site inventory and previous archaeological site surveys and excavations. In describing the current inventory, various summary statistics by time period, cultural complex, site type, resource condition, terrain type associations, etc. are provided. The inventory contains 1 872 recorded sites, including 1 474 prehistoric sites, 90 post-contact or historic sites, and 308 sites of unknown cultural or temporal affiliation.

Historic sites generally date to the turn of the century or earlier and may be Euro-Canadian, Metis or Native Indian affiliation. They invariably represent early trading posts, historic trails, homesteads, farmsteads, ranches or other settlements and special use areas. Significant examples include: the Huxley ranch, a log cabin reportedly built before 1886; Batoche, site of the final battle of the Northwest Rebellion; the Saskatchewan Landing North West Mounted Police post located on the south bank of the South Saskatchewan River; and, the "Battle of Red Ochre" site, a reported Blackfoot Indian battle site in the Vermillion Hills.

Of the 1 976 prehistoric period components (from 1 474 sites), 516 are Late Prehistoric in age (170 to 2 000 B.P.), 448 are Middle Prehistoric (1 850 to 7 700 B.P.), 70 are Early Prehistoric (7 700 to 11 500 B.P.) and the remainder are unspecified. The majority of known sites are simple artifact scatters, followed by artifact finds and sites consisting of a combination of surface features (e.g. tipi rings and cairns) and artifacts.

Fifty-one "sites of a special nature" - those afforded special protection under Saskatchewan's Heritage Property Act - are known, including three medicine wheels, four boulder effigies, eight boulder alignments or petroforms, 20 definite and 15 probable human burials, and two rock art sites.

Four distinct archaeological sensitivity zones, each unique in the type, density, visibility and location of sites which may be expected, were defined in SSRBS Technical Report E.16. Zones 1 and 2 (valley complex and sand hills, respectively) were primary habitation areas for large social groups commonly engaged in communal bison hunting. Zone 1 had a higher human carrying capacity than Zone 2 and was consequently more intensively used. Large sites, such as base camps and communal kills, may be expected in these zones in addition to smaller, transitory camps and ceremonial locations.

Zones 3 and 4 (moderate to strongly rolling and flat to gently rolling terrain, respectively) were mainly occupied in a periodic or transitory manner by small groups. Sites here are typically small, short-term occupations, frequently consisting of tipi rings and containing few artifacts.

8.1.2 Palaeontological Zones

Vertebrate palaeontological resource sensitivity zones were identified largely on the basis of existing inventory data and previous research. A report by the Saskatchewan Research Council on key geological formations between Saskatchewan Landing and the Alberta border was also consulted as part of the SSRBS Technical Report E.16. Most fossil-bearing deposits were found to be exposed west of Lake Diefenbaker.

Two types of sensitivity zones are defined. The first represents areas of high potential which contains abundant resources. Here, impact assessment, mitigation, or other protective action would be required in advance of water resource development. The second type of zone represents more moderate heritage site potential, containing scattered resources. In most cases, these resources can be sufficiently protected by means of incidental development or construction monitoring.

Typical examples of fossil vertebrates discovered in the study area include the articulated skeletons of marine reptiles (mosasaurs and plesiosaurs) in the Herbert Ferry to Saskatchewan Landing area; dinosaur bones northeast of Cabri; and Pleistocene fossil vertebrates from gravel pits and gravelly cutbanks in the Outlook-Danielson area.

8.2 REVIEW OF POTENTIAL IMPACTS

The archaeological and vertebrate palaeontological sites of the study area are characterized as non-renewable, measurably finite, and highly fragile (cultural) resources. As physical and often very inconspicuous components of the landscape, they are particularly vulnerable to destruction from land disturbances. Heritage resources in Saskatchewan are generally recognized as having several kinds of significance to contemporary society, including scientific, humanistic (or social), and economic significance as recreation and tourism attractions. Data recovered from archaeological and palaeontological sites also have practical application to other disciplines (e.g. regional planning, engineering, medicine, paleogeography).

8.2.1 Reservoir Development

The construction and operation of Lake Diefenbaker and the related agricultural, recreational, residential and industrial development of the region has had, and continues to have, a significant adverse impact on the heritage resource. The specific mechanical and biochemical effects of dam construction, inundation, reservoir operation and intensified land use are described below. Principal among these impacts are: destruction of site features; destruction or alteration of spatial and stratigraphic patterns; and the differential preservation or displacement of heritage objects and attribute data.

During construction of the Gardiner and Qu'Appelle dams between 1958 and 1968, impacts on heritage sites would have resulted from various activities including: dam, spillway, borrow pit and road construction; gravel stockpiling; and bank stabilization, landscaping and other earth movement. Although dam construction-related impacts were localized and affected perhaps fewer than 30 archaeological sites, virtually total resource removal or destruction would have occurred. Impacts from the filling and subsequent operation of Lake Diefenbaker would also have been significant and certainly more extensive.

Reservoir processes that affect the preservation and analytical value of archaeological remains are both mechanical and biochemical (Lenihan et al. 1977, Garrison 1977, Matheson, 1989). Biochemical impacts result from changes in river chemistry (e.g. temperature, pH, dissolved oxygen, $C0_2$, etc.), soil chemistry, rates of microbial activity and decomposition, and other aquatic ecosystem components as a consequence of reservoir development. While their effect on the differential preservation of archaeological remains within a site is less predictable, virtually every artifact category, with the exception of some lithic material, is potentially affected.

Mechanical processes include wind-generated waves and currents, sediment saturation, and siltation. Nearshore waves and wave-induced currents are generally responsible for the majority of mechanical impacts. Their erosional effect on heritage sites can be extensive - for example, the removal of a metre or more of cultural deposits over relatively short periods has been documented (from Lenihan et al. 1977: 102-106). Impacts are especially severe in large reservoirs subject to extensive water level fluctuations which effectively increase the beach area exposed to the destructive action of nearshore waves and currents. Furthermore, once the stabilizing surface vegetation is removed as a result of periodic inundation, heritage sites become increasingly susceptible to various secondary erosional processes such as ice scouring, surface runoff and wind deflection.

The Lake Diefenbaker shoreline is still actively eroding. The location and rate of erosion is dependent on several factors including: wind velocity, duration and direction; fetch; nearshore slope; shoreline topography and soil properties; aspect; and pool level fluctuations. In their study of shoreline erosion between 1970 and 1979, J.D. Mollard and Associates (1984) calculated that the rate of erosion in the first year of a reservoir operation was substantial - possible 50 to 100 percent higher than the 10 year average. Headlands projecting into the lake eroded first and fastest followed by intervening bays and other protected shoreline segments. During the study period, cliffed shorelines eroded between 1.0 and 4.0 metres per year, or more in some situations. Although this rate is expected to decrease in future, the process of beach formation is still very active (SSRBS Technical Report C.9). Ebert et al. (1989) report a comparable erosion rate of 1.8 to 3.5 metres per year in their comprehensive assessment of archaeological sediments at reservoirs along the Middle Missouri River in North Dakota, South Dakota and Nebraska. However, their results indicate that, following reservoir filling, erosion rates do not slow or level off quickly "...at least at the sites studied here over a period of as much as 30 years" (Ebert et al., 1989).

Slope regression or movement since reservoir development was also examined by Mollard. They found that locations "above and near the toe of eroded slumps and just below and just above the topmost headscarp of the valley side" (J.D. Mollard and Associates 1984) were most susceptible. Measured rates of slope movement varied from 20 to 50 mm/year.

By comparison, the extent or degree of mechanical impact in the permanently inundated offshore zone of a reservoir is minimal. However, the saturation of sediments can cause substantial offshore erosion, including slope failure, slumping, and creep, thus affecting sites which otherwise may have withstood the effects of inundation. Siltation is another potential concern. However, in one sense, the burial of heritage sites during reservoir sedimentation can be beneficial by prohibiting mechanical, biochemical or other destructive impacts. However, as Lenihan et al. (1977) have pointed out, the virtual inaccessibility of these buried sites for scientific or other use poses other problems. As well, the weight of accumulated sediments may eventually warp or otherwise damage archaeological and palaeontological deposits.

The specific effects of dam construction, inundation, and reservoir operation on archaeological and palaeontological sites may include any one or more the following:

- destruction or alteration of site features (e.g. hearths, storage pits, middens, etc.);
- loss or alteration of geomorphological features, soil structure, soil chemistry, or other chemical patterns within a site;
- destruction or alteration of spatial and stratigraphic patterns and relationships within a site;
- selective removal or displacement of artifacts or palaeontological specimens by size, shape and density;
- loss of artifact attribute data due to mechanical abrasion and other physical impacts;
- differential preservation of individual artifact categories or classes of data (especially organic or other perishable remains) due to biochemical deterioration (e.g. ceramic, floral and faunal remains are particularly vulnerable to deterioration from the wet-dry cycle associated with periodic inundation);
- loss or alteration of radiometric data.

These physical and chemical impacts reduce the scientific and public value of heritage sites by compromising or precluding certain cultural/behaviourial studies, analytical techniques, temporal interpretations, paleo-environmental reconstruction, recreational development opportunities, and the like. In the absence of a comprehensive site inventory and any sustained monitoring program, the true extent to which sites within the study area have been or still are affected by reservoir processes is undeterminable. It is notable, however, that previously unknown sites are routinely reported at low lake levels when the effects of shoreline erosion are most visible (e.g. Germann and Thomas 1988, Johnson 1988, Millenium 1989).

Completion of the Lake Diefenbaker reservoir resulted in increased agricultural, recreational and industrial use of the region. These intensified land uses and related developments (e.g. irrigation pumping stations and pipelines, recreational cottage subdivisions, roads, and power facilities) would also have adversely affected heritage sites. To this list could be added shoreline impacts from grazing animals, mechanical impacts from increased discharge of industrial wastes, and biological impacts from the organic enrichment of water. Of particular importance is the likely increase in site vandalism (e.g. unauthorized artifact collection) as a result of improved access, increased recreational land use, and increased site visibility due to shoreline erosion. Again, the magnitude of impact from these sources cannot be quantified at this time.

8.2.2 Future Water Resource Development

As the only reliable source of good quality water in the southern part of the province, further development of the water resources within the study area is probable. In the context of reservoir operation, the development of new facilities may be required to regulate the flow and level of water (e.g. pumping stations) or to maintain water quality standards (e.g. construction of new waste treatment plants). New development may also be needed to meet the increasing needs of existing users for irrigation, recreation, power generation, municipal water supply, etc., as well as users not yet established in the basin. The types of developments which may be expanded or initiated within the basin include irrigation, recreation and tourism development, municipal developments and hydro-electric projects. The possible adverse impacts of each of these types of development on heritage resources are briefly discussed below.

To date, only 15 percent (30 000 ha) of the total area which is potentially irrigable from Lake Diefenbaker has been developed (SSRBS Technical Report A.1). Clearly, the irrigation potential of the basin has not been reached.

Irrigation-related impacts on heritage sites would result from construction of pumping stations, pipelines or canals, and possible channel rehabilitation, diversions and storage reservoirs. As well, increased irrigation could result in reduced flows and, in turn, an increase in salinization, nutrient loading and potential contamination. However, while decreases in flow could adversely affect some sites, it could reduce erosional impacts in other cases. Finally, the consequences of increased irrigation potential, particularly increased agricultural development, must be considered.

It is generally recognized that the study area, and Lake Diefenbaker in particular, has substantial, untapped recreational and tourism potential (Hilderman et al. 1983). As such, considerable new recreation and tourism development within the basin may be expected.

Impacts on heritage resources from recreational development are primarily associated with required infrastructure (e.g. new roads, marinas, parks, camping facilities, trails, golf courses, sewer systems and related works). The judicious siting of these facilities will minimize or avoid direct adverse impacts. Indirect impacts attributable to increased or improved public access such as site vandalism may also be significant.

The construction of any water management control structures will usually have a relatively limited impact on heritage sites. Furthermore, the location or alignment of some facilities, such as pumping stations or canals, are often sufficiently flexible to accommodate heritage site avoidance. Impacts resulting from water conveyance or stream channelling will also be minimized where these activities follow the low-lying, seasonably inundated areas as is often done. However, the development of new impoundments or raising of existing water bodies beyond historic highs cause more serious impacts.

Typical municipal water resource developments which may adversely affect heritage resources include new or expanded storage reservoirs, control and pump stations, and waste treatment plans. Most impacts are related to the location of facilities, and therefore, can be mitigated through proper siting procedures.

Various opportunities for increasing hydro-electric power production, both through the construction of new dams and through expansion of existing facilities, have been identified (SSRBS Technical Report E.2). Impacts associated with these opportunities would result mainly from the construction of earthfill dams, spillways, borrow pits and related work, and from the mechanical effects of reservoir development and operation. Provided no significant alteration of levels is proposed, any possible expansion of the existing power plants would have only a limited adverse impact.

In the context of future water resource management and development, the following archaeological impact assessment and management requirements may be anticipated. Comprehensive field survey and sub-surface testing will likely be required to assess most development proposals in Zone 1. Deep probing may be required along river terraces and valley or coulee bottoms. As well, many sites in Zone 1 may require salvage excavation or other comprehensive data recovery prior to development. Generally only projects involving moderate to large scale impacts will require comprehensive assessment in Zone 2. Sub-surface testing and trench monitoring would be routinely employed. Site survey and assessment (including sub-surface testing) will be necessary for most developments in Zone 3, especially those proposed in undeveloped areas. Impact mitigation (e.g. salvage excavation) will generally be more limited in scope. In Zone 4, site survey and assessment may be necessary for large-scale developments, especially in uncultivated areas. (Zones are those defined in SSRBS Technical Report E.16).

9.0 WETLANDS

Wetlands in Canada consist of bogs, fens, swamps, marshes and shallow open water areas such as prairie potholes. Wetlands have important ecological, hydrological and recreational functions. They are valuable habitat for a wide range of wildlife and unique plant species as well as playing a crucial role in the hydrology of watersheds by moderating flood peaks and storm flows, modifying water quality, and buffering shorelines against erosion.

It is only recently that the values and benefits of wetlands in Saskatchewan have been articulated (Brace and Pepper 1984, Young 1989, Saskatchewan Task Force on Soil, Water and Wetlands 1990, Young and Thompson 1990). Briefly summarizing, wetlands (including those in the study area) contribute to:

- Hydrological Functions
  - Collection and storage of run-off, groundwater recharge
  - Flood protection and erosion reduction
  - Water purification
  - Hydrological cycling (i.e., contribution to rainfall)
- Habitat Functions
  - Support of a broad diversity of fauna and flora
  - Support of rare and endangered species (including piping plovers and whooping cranes)
- Ecological Functions
  - Contributions to ecological diversity, and processes such as oxygen generation and nutrient cycling
- Socio-economic Functions
  - Agricultural support - stock watering, haying
  - Basis for economic policies/programs such as NAWMP
  - Commercial hunting, trapping and fishing
  - Non-consumptive use such as bird-watching
  - Existence value - quality of life considerations
- Educational Functions
  - Used for scientific research
  - Used for education - interpretive tours for schools

9.1 WETLANDS ASSESSMENT

The study area contains an abundance and broad diversity of wetlands. For example, a study of 15 townships (3.7 percent of the study area) in the R.M.s of Lost River and King George, revealed the presence of over 14 000 wetlands totalling over 11 000 hectares (Young and Thompson 1990). This information was derived from 1:20 000 black and white airphotos. With the data base available for delineating wetlands in this study (1:250 000 NTS maps of various vintages), it was feasible to identify only the larger wetlands illustrated on those maps. Of these, approximately 2 500 were classified as intermittent and they amounted to approximately 71 000 ha (Table 10). Permanent wetlands, including lakes accounted for 116 in number, with a surface area of approximately 8 500 ha (Table 10). The number of wetlands documented in this study represent only a small fraction of the total number of wetland basins in the study area.

Another important factor to consider is that the source of data is not current. The available maps illustrated conditions during the mid-1970s and 1980 (see Table 10). Recent investigations of wetland status in the Prairie provinces have revealed that many of these wetlands have been degraded or lost during the 1980s as a result of drought conditions coupled with drainage and cultivation. The data base on wetlands is therefore in need of an update.

9.2 WETLANDS AND WATER MANAGEMENT

The Canada/United States Steering Committee (1986) reported that approximately 40 percent of the wetlands in the prairie-parkland region of Canada have been lost since the turn of the century. More recently, Environment Canada (1989) placed this loss even higher, 70 percent, in the Central prairies. In the 1980s alone, Turner et al. (1987) reported that for the period from 1981 to 1985, an average of 59 percent of Saskatchewan's wetlands were impacted by agricultural practices on an annual basis. These impacts related primarily to cultivation and burning, with drainage during this period not exceeding 1 percent of the wetlands on an annual basis (op. cit.).

TABLE 10	NUMBER OF TYPES OF WETLANDS IN THE SOUTH SASKATCHEWAN RIVER BASIN AS DETERMINED FROM 1:250 000 NATIONAL TOPOGRAPHIC SERIES MAPS[a]	
WETLAND TYPE	NUMBER OF WETLANDS	SURFACE AREA (Ha)
INTERMITTENT	2 499	70 727
PERMANENT	116	8 524
TOTAL	2 615	79 351

[a]

MAP	MAP PRODUCTION DATE
72F	1974
72G	1972
72J	1980
72K	1980
72N	1980
72O	1979 (N1/2), 1980 (S1/2)
72P	1980
73A	1976
73B	1976
73C	1976
73G	1977
73H	1980

In recognition of Saskatchewan public interest in the province's wetland resources, the Government of Saskatchewan appointed a task force to solicit input from the public on how to best manage that resource. Conclusions arising from that exercise (Task Force on Soil, Water and Wetlands Management in Saskatchewan 1990) included:

- A comprehensive long-term land use policy should be developed which encourages sustainable development
- The importance of the province's wetland resources must be communicated through the school system and to adults
- An interdisciplinary committee be established to coordinate and integrate the numerous programs associated with water and wetland conservation
- The government should ensure that farmers receive a realistic return on investment in return for farmers adopting farming practices which benefit society as a whole
- Farmers should be allowed to make decisions dealing with water management providing those decisions comply with government water policies
- Stricter control on effluent releases and rehabilitation of contaminated waterbodies
- Review of existing environmental protection regulations and upgrading, where necessary plus enforcement
- Inventory of wetlands to ensure that sufficient numbers can be maintained to maintain environmental integrity
- Encourage research addressing conservation techniques and improvement of wetland quality
- Farmers should be fairly compensated for supporting wildlife for which society derives benefits
- A pro-active approach (including legislation) needs to be developed to address the problem of unauthorized drainage
- In recognition of the multiple functions of wetlands, a program should be developed to promote the creation of artificial wetlands
- Existing measures to protect permanent waterbodies from exploitation should be enforced for both Crown and private lands

The Task Force findings coupled with those from the Young and Thompson (1990) study reveal compelling reasons for the conservation of Saskatchewan's wetland resources. The most significant findings are that society in general and the landowner who has wetlands on his/her property are now recognizing the intrinsic value of wetlands beyond the potential for drainage and bringing more area into production for agricultural commodities.

10.0 ENVIRONMENTALLY SENSITIVE AREAS

A variety of different natural environments may be found within the study area, including forests, open prairie, parkland, lakes and rivers, and even desert-like sand dunes. The importance of these different, and often unique, regions has long been recognized, and measures have been taken to ensure their protection under legislation such as the provincial Ecological Reserves Act.

Eleven environmentally sensitive areas (ESAs) representing approximately 1 440 000 ha or some 38 percent of the study area have been identified within the South Saskatchewan River Basin, primarily on the basis of their vulnerability to human-related disturbance. Such areas also include those landscapes which are distinctive or unusual in a local, regional or national context and have aesthetic, biological or educational value. Sensitive areas have been described within four broad categories: sensitive terrain; sensitive parent material (soil-forming material); sensitive drainage features; and, sensitive soils. Brief descriptions of each sensitive area type are presented in the following section, while their areal extent within the study area is provided in Table 11. The locations of these areas are illustrated in the environmentally sensitive areas map folios.

10.1 SENSITIVE TERRAIN TYPES

10.1.1 High Relief, Undulating to Rolling Topography

This terrain type includes the rolling to undulating uplands within the South Saskatchewan River Basin which have formed through the deposition of unsorted glacial sediments. It occupies approximately 14 percent of the study area (Table 11). Type topography consists of undulating plains and strongly rolling terrain which is characterized by a mosaic of knolls and intervening depressions (knob and kettle topography). Other terrain features include ice-thrust ridges, linear ridge moraine, washboard ridges and end moraine. Such terrain is largely used as native range with vegetation, comprised of spear grass, June grass, wheat grasses and blue grama grass. Shrubs such as snowberry, sagebrush, rose and saskatoon are found in more moist depressions. The topographic diversity of this terrain type affords valuable wildlife habitat for such species as mule deer, antelope and upland game birds.

The sensitivity of this terrain results from a variety of factors including slope angle, depth of parent material and drainage conditions which can lead to localized wind and water erosion following surface disturbance.

10.1.2 Meltwater Channels - Moderately Eroded Terrain

Meltwater channels are remnant drainage features formed by retreating glaciers and the subsequent formation of spillway routes from large glacial lakes which once dominated much of the prairie landscape. Downcutting of these drainage channels has produced extensive U-shaped valleys, with distinctive channel margins. Those channel margins which have been classified as "moderately dissected" occupy approximately 2 percent of the study area.

The slopes consist of rolling, rounded crest and swale topography which often have a symmetrical, wave-like patterns from slope crest to valley margin. At lower elevations, such slopes can give way to level terraces or benches which have formed adjacent to the river or creek channel. Where the walls of the meltwater channel have experienced extensive erosion to form ravine or gulley complexes they have been mapped separately as Gulley Complex (following section); however, where the valley sides are only moderately dissected and largely vegetated they have been included in the present category.

A mosaic of grass and shrub associations characterizes the native vegetation of these slopes, where the rounded slope crests support a variety of grass species such as spear grass, June grass, wheat grass and blue grama grass while the intervening depressions are characterized by dense shrubby species such as characters, saskatoon and buckbrush. These areas are important from a wildlife habitat perspective where mule deer, furbearers and raptors utilize the variety of topography an vegetation types afforded by this terrain type.

The sensitivity of this landscape to erosion is due to steep, often unstable slopes which are difficult to revegetate. Springs and seepage sites are often found in association with break of slope positions which lead to localized saturated soils with low trafficability. Detailed, site specific development and reclamation plans are required to ensure that erosion is minimized as a result of any development within this terrain type.

TABLE 11	ENVIRONMENTALLY SENSITIVE AREAS IN THE SOUTH SASKATCHEWAN RIVER BASIN AS DETERMINED FROM THE 1:250 000 TERRESTRIAL WILDLIFE HABITAT INVENTORY LAND SYSTEM MAPS	
DESCRIPTION	AREA (ha)	PERCENT OF TOTAL BASIN AREA
TERRAIN		
High Relief	534 982	14.28
Moderately eroded meltwater channels	82 943	2.21
Highly eroded terrain - gully complex	146 678	3.92
PARENT MATERIALS		
Aeolian	299 492	7.99
Alluvium	77 186	2.06
SENSITIVE DRAINAGE FEATURES		
Active floodplain and tributaries	43 697	1.17
Organic wetland and fenland	6 809	0.18
SENSITIVE SOILS		
Predominantly saline soil area	28 613	0.76
Patchy saline soil area	5 763	0.15
Predominantly hardpan solonetzic soil	123 806	3.30
Patchy hardpan solonetzic soil	89 579	2.39

10.1.3 Gully Complex - Highly Eroded Terrain

This terrain type consists of the steeply sloping gulley and creek margins associated with both active and inactive drainage channels. As such, these areas comprise some of the most varied topography in the region and occupy approximately 4 percent of the study area. The soils are usually highly susceptible to water erosion due to silty or clayey textures, high relief and steep slopes. Northerly or southerly aspects also allow large diurnal and seasonal temperature changes which contributes to freeze/thaw cycles and slope erosion processes. Natural vegetation cover is often absent or sparse on extreme slopes of the coulee or creek banks; this is due to severely limiting soil conditions which typically have a high salt content derived from the underlying bedrock material, in addition to a lack of structure or organic matter. Lower slopes and coulee bottoms support a dense and varied association of shrubs and grasses which provide an important source of food and cover for a variety of wildlife species.

The vegetation and wildlife associated with this terrain type is distinctive and diverse. Coulees and creek banks often provide critical habitat for mule deer (especially in winter) as well as for raptors and furbearers, while the upland margins of such terrain also have a high potential for archaeological sites and offer considerable scenic value.

The occurrence of this sensitive terrain type adjacent to intermittent or perennial stream channels necessitates special erosion control measures to protect downstream quality. The high relief and steep, dissected slopes limit access and require extensive grading for access roads.

10.2 SENSITIVE PARENT MATERIAL

10.2.1 Aeolian - Non-Stabilized, Wind-Borne Deposits

Aeolian terrain is characterized by a mosaic of sand plains and dunes of varying relief, formed through glacial deposition and subsequent reworking by wind action. Such terrain which includes the Great Sand Hills area, occupies approximately 8 percent of the study area.

Two relief classes can be recognized within this terrain type. The high relief dune fields are characterized by rolling, stabilized dunes, separated by level to undulating sand flats and frequent blow-outs as well as the occurrence of localized, active dunes. Dunes are typically parabolic or irregularly linear in form. Low relief dune fields occur as undulating to gently rolling topography with localized areas comprised of small, stabilized blowouts within a smooth, undulating, arid grassland.

The landforms, soils, vegetation and wildlife of aeolian terrain are distinctive and have considerable diversity (Epp and Townley - Smith 1980, Hart and Hunt 1980). In addition, such areas also have high archaeological, aesthetic and recreational values.

As the soil surface is poorly vegetated, it is easily disturbed by vehicle traffic and overall has a low tolerability to such disturbance. Erosion control and revegetation requires specialized and often expensive practices as reestablishment of native species is slow due to the coarse texture of the substrate and low level of water and nutrients available to plants.

10.2.2 Alluvium - Fine-Textured, River-Borne Sediments

The near level to depressional alluvium sediments associated with the various drainage channels in the area occupy approximately 2 percent of the study area. Such lands consist of post-glacial, water-borne sediments which have been deposited within the former channel margins of once active floodplains.

The low-lying alluvial sediments are identified by their level appearance and topographic position where they mark the boundary between the floodplain and the adjacent valley side of major drainage channels. The vegetation consists of predominantly grassland such as spear grass, wheat grasses and blue grama grass interspersed with clumps of snowberry, rose and sagebrush.

Sediments are typically fine-grained silt and sands which have been successively deposited during flood events. Frequently such areas are poorly drained and may tend towards excessive salinity. For these reasons they are sensitive to disturbance and are difficult to reclaim once the surface vegetation cover has been removed. In addition, the undifferentiated nature of the alluvial sediments limits soil structural development and leads to poor trafficability of such soils.

10.3 SENSITIVE DRAINAGE FEATURES

10.3.1 Active Floodplains and Tributaries

This terrain type includes the active floodplains and tributaries of the various drainage channels within the study area. Typically this comprises of meandering streams, braided channel margins and the narrow, incised portion of the creek bank which separates the drainage channel from the adjacent upland. Just over 1 percent of the study area is comprised of this terrain type.

The native vegetation is dominated by shrub species such as wolf willow, buckbrush, rose and snowberry. Such areas often provide "woody islands" surrounded by grassland or cultivated upland and are subsequently important in providing both food and cover for a variety of wildlife species.

The sensitivity of this terrain to disturbance is evident in the form of steep, often incised slopes and the proximity of rapidly fluctuating water flows. The poorly consolidated nature of the till material through which much of the drainage channels flow means that any in-stream disturbance requires strict erosion and sedimentation control. Aesthetic impacts are also of concern within such highly sensitive drainage features.

10.3.2 Organic Wetland Complex

Organic wetlands, comprised of a thick accumulation of sphagnum moss or peat, are associated with stagnant, nutrient-poor water which is strongly acidic. The wetland complex typically occurs as a mosaic of shallow water, interspersed with willow species, shrubby bog birch, sedge and other highly adapted vegetation. Less than 1 percent of the study area is characterized by this terrain type.

Such areas are highly sensitive to disturbance of any kind, as their occurrence is typically due to a localized unique hydrologic and topographic condition. Poor bearing strength, widely fluctuating water levels and low resilience to physical disturbance severely limits reclamation success should these areas be disturbed. Such areas often provide localized habitat specific to rare and endangered species.

10.3.3. Organic Fenland

Fenland consists of low-lying, poorly drained organic deposits formed by a thick accumulation of primarily sedge-peat, enriched by slow moving, slightly acidic to alkaline soil water. As in the case of the previous organic wetland type, less than 1 percent of the South Saskatchewan River Basin is characterized by this type. Sedges and specially adapted grasses comprise the dominant vegetation cover.

Terrain sensitivities are as described for the organic wetland complex. Additional restraints on reclamation often include saline soil conditions in association with areas of groundwater recharge.

10.4 SENSITIVE SOILS

10.4.1 Predominantly Saline Soils

Areas of saline soils are associated with generally level to depressional topography occurring on poorly drained alluvial or lacustrine land. The salt or alkali deposits, primarily sodium sulphate, magnesium sulphate and sodium chloride, originate from artesian aquifers or from run-off water carrying dissolved materials from glacial till. These soils have developed through both natural processes and cultivation of dryland areas. Their distribution is quite variable, although extensive tracts of saline soils do occur throughout the study area. A total of approximately 1 percent of the study area has been classified as predominately saline soil.

The vegetation of these areas is often patchy and generally dominated by salt tolerant grasses such as western wheat grass, wild barley and Nuttall's salt meadow grass. Other distinctive species include red samphire which often forms a carpet around the margins of saline lake beds.

Terrain sensitivity is due to the poorly drained nature of these areas in association with extremely low trafficability of the soil. The presence of chloride and sulphate salts contributes to a breakdown of soil structure so that soils are hard and cloddy when dry, but soft and sticky when wet. Revegetation efforts on such sites are difficult because of poor soils quality and limited selection of plant species which can tolerate these conditions. These areas are often locally subjected to seasonal inundation from spring run-off.

10.4.2 Patchy Saline Soils

This land type includes those areas which may have the occasional area of saline soils but are too small to map at the present mapping scale. It occupies less than 1 percent of the study area. Such sites are often associated with local seepage sites such as are found at break of slope areas or at groundwater discharge sites. Physically and chemically these areas are similar to the more extensive saline areas described in the previous section. Terrain sensitivity is also similar within the context of sensitivity to man-induced disturbance.

10.4.3 Predominantly Solonetzic (Hardpan) Soils

Solonetzic soils are thought to have developed from parent materials that were generally salinized with salts high in sodium. Leaching of this parent material, combined with other soil forming factors has led to the formation of an extremely hard subsoil (hardpan) which limits water and nutrient through-flow resulting in strongly alkaline soils which are difficult to work and may be of low fertility. Such solonetzic soils occupy approximately 3.5 percent of the study area.

Topographically, solonetzic soils resemble those areas affected by saline soils, occurring generally flat to depressional landforms. Distinctive micro-relief features in the form of shallow "burn-out" pits or eroded hollows are also characteristic. Rangeland is the predominant use of such soils.

The sensitivity of Solonetzic soils lies in their limitations to successful revegetation. The thin, often discontinuous topsoil and very dense subsoils with strongly saline and sodic properties severely restrict revegetation of disturbed areas. Special operational guidelines are required to avoid reclamation problems.

10.4.4 Patchy Solonetzic (Hardpan) Soils

Approximately 2.5 percent of the study area is classified as having occasional areas of solonetzic (hardpan) soils. These areas are too small to map individually at the present mapping scale; however, their patchy distribution has been identified on the basis of existing, mapped data sources. Terrain sensitivity is similar to that of the more extensively mapped solonetzic soils where poor soil structure and high sodicity severely limit revegetation efforts on disturbed soil.

11.0 LAND TENURE

Although land tenure per se is not an environmental resource, an understanding of land tenure is important as it is the key element contributing to potential protection of the study area resources. Generally speaking, government land is better protected from development than private land. Furthermore, the documentation of land tenure is relevant in terms of identifying areas which might be susceptible to disturbance/degradation.

The vast majority of the study area is comprised of private land (83 percent) and leased crown land (8 percent) as indicated in Table 12. The balance of the land is apportioned in small percentages to a broad variety of designations.

Land tenure in the South Saskatchewan River Basin as determined from the province's Terrestrial Wildlife Habitat Inventory Land Tenure maps is illustrated in the Land Tenure map folio, and the surface area for each designation is presented in Table 12.

TABLE 12	LAND TENURE FOR THE SOUTH SASKATCHEWAN RIVER BASIN AS DETERMINED FROM 1:250 000 TERRESTRIAL WILDLIFE HABITAT INVENTORY LAND TENURE MAPS	
LAND TENURE	**AREA (ha)**	**PERCENT OF TOTAL BASIN AREA**
Privately owned land	3 099 346	82.73
Privately leased, provincial crown land	296 927	7.93
Pasture (PFRA, Provincial Community and Co-op)	152 581	4.07
Provincial Land Bank land	32 139	0.86
Wildlife Development Fund land	484	0.01
Vacant crown land	80 726	2.15
Canadian Wildlife Service land	1 257	0.03
Saskatchewan Parks and Renewable Resources land	45 254	1.21
Agriculture Canada land	142	0.004
Potash Corporation of Saskatchewan	5 570	0.15
SaskPower	369	0.01
Department of National Defence	7 908	0.21
Indian Reserves	18 371	0.49
Federal Bird Sanctuary	348	0.01
National Historic Sites	1 288	0.03
Regional Parks	56	0.001
Other	1 086	0.03

12.0 CONCLUDING SUMMARY

The study area supports a broad diversity of wildlife. From a waterfowl perspective, the study area contains waterbodies which are of high importance for staging (particularly Lake Diefenbaker) and moulting, and a considerable portion of the basin has been designated for project implementation under the multi-million dollar North American Waterfowl Management Plan because of its high quality breeding habitat.

Information on rare/endangered wildlife species is limited and quantitative information is restricted to three species: the piping plover, ferruginous hawk and burrowing owl. The proportion of Saskatchewan breeding areas for each of these species that occurs in the study area amounts to 32, 16, and 16 percent respectively.

Critical habitat as designated by the Province of Saskatchewan occurs throughout the study area for a number of species. These include big game such as mule deer, furbearers such as beaver, upland game birds like the sharp-tailed grouse, and raptors like prairie falcons. The highest proportion of the study area that constitutes critical habitat for any one species is 7 percent for white-tailed deer. In total, 408 287 ha or 11 percent is comprised of critical wildlife habitat.

Water management and water resource developments have the potential to affect wildlife resources. These impacts could occur in the form of habitat loss through inundation by a reservoir or more indirectly through wetland drainage or cultivation of grassland areas prompted by improved access to irrigation water. On the positive side, wildlife, particularly waterfowl, can benefit from the water provided by reservoirs or wildlife projects such as those of Ducks Unlimited that can be developed in association with irrigation projects.

Of the 27 fish species resident in the study area, 10 are considered sportfish. The South Saskatchewan River and its major tributaries represent a managed river system. The impoundment of this river has resulted in changes to the physical characteristics of the river above and below the impoundments, with associated variable effects on the fish fauna. Factors that must be considered in evaluating existing effects and future water management on the fisheries resource include hydrology, water quality, vegetation and benthic invertebrate communities. The abundance and distribution of fish, particularly the South Saskatchewan River, have developed in response to the highly variable flows that occur in this system. In order to protect or enhance the fisheries resource, through future water management decisions, detailed investigations of the biotic and abiotic variables will be required.

The study area contains an abundance and broad diversity of wetlands. The data base on wetlands is, however, old and needs to be updated. These wetlands play a valuable role hydrologically and ecologically and from a socio-economic perspective. Recent initiatives by the Government of Saskatchewan, coupled with public expressions of interest, have revealed a desire to protect and enhance Saskatchewan's wetland resources. Of particular interest with regard to water management are opportunities for co-operative efforts between agricultural and wildlife to effectively utilize water and wetland resources.

Fourteen International Biological Program (IBP) or Natural Areas occur in the study area. These sites are noteworthy because of their assemblage of flora, fauna and physiographic features. These areas, which are distributed throughout the basin constitute 48 112 ha or 1.3 percent of the basin.

Eleven environmentally sensitive areas were identified in the study area, primarily on the basis of their vulnerability to human-related disturbance. These sensitive areas were described within four broad categories, terrain, parent material, drainage features and soils. These areas represent approximately 1 440 072 ha or 38 percent of the South Saskatchewan River Basin.

Heritage resources are well represented throughout the South Saskatchewan River Basin. Almost 1 900 sites are known, approximately 1 500 of which represent prehistoric sites (e.g., tipi rings), 90 of which are post-contact (i.e., European settlement) or historic sites and 300 sites of unknown affiliation. It should be noted that these represent only the known sites and because of the attractive features of the river valleys to natives and European settlers, there is undoubtedly a rich heritage resource that has not yet been fully discovered. The extant heritage resources are non-renewable, finite and highly fragile. They are particularly vulnerable to disturbance associated with construction of dams, irrigation canals and other physical works.

13.0 LITERATURE CITED

Adams, C.I.G. 1985. Natural Areas in Saskatchewan: A Review of the IBP System. Prep. for Saskatchewan Natural History Society.

Alberta Forestry, Lands and Wildlife. n.d. Bow River recreational study, an assessment of recreational use and economic benefits, Volume 1: Summary. Edmonton.

Allen, A.W. 1983. Habitat suitability index models: beaver. 82/10.30 Revised. United States Fish and Wildlife Service.

Bailey, R.O. 1983. Use of southern boreal lakes by moulting and staging diving ducks. pp. 54-58. In: Boyd, H. (ed.) Proc. first western hemisphere waterfowl and waterbird symposium. Edmonton, 1982. Supply and Services Canada. 147 pp.

Banfield, A.W.F. 1974. The mammals of Canada. University of Toronto Press, Toronto. 438 pp.

Barrett, M.W. 1980. Seasonal Habitat Associations of Pronghorns in Alberta, Proceedings of the 9th Biennial Pronghorn Antelope Workshop, Rio Rico, Arizona.

Barrett, M.W. 1974. Importance, utilization and quality of Artemesia cana on pronghorn winter ranges in Alberta. Antelope States Workshop Proc. 6:26-57.

Beard, E.B. 1964. Duck brood behaviour at the Seney National Wildlife Refuge. J. Wildl. Manage. 28: 492-521.

Bellrose, F.C. 1976. Ducks, geese and swans of North America. Second Edition. Stackpole Books, Harrisburg, PA. 544 pp.

Bellrose, F.C. 1979. Species distribution, habitats, and characteristics of breeding dabbling ducks in North America. pp 1-15. In T.A. Bouckhout (ed). Proc. of a symposium on waterfowl and wetlands: an integrated review - LaCrosse Printing Co. LaCrosse, Wisconsin.

Berg, P.F. 1956. A study of waterfowl broods in eastern Montana with special reference to movements and relationship of fencing to production. J. Wildl. Manage. 20: 253-262.

Berg, W.E. and R.L. Phillips. 1974. Habitat use by moose in northwestern Minnesota with reference to other heavily willowed areas. Naturaliste Can. 101:101-116.

Bossenmaier, E.F. and W.H. Marshall. 1958. Field feeding by waterfowl in southwestern Manitoba. Wildl. Monogr. No. 1. Wildl. Soc. Washington, D.C. 32 pp.

Brace, R.K. and G.W. Pepper. 1984. Impact of agricultural drainage on wildlife. In Proc. Western Conf. on Soil and Water Manage. pp 451-481.

Bovee, K.D. 1982. A guide to stream habitat analysis using the instream flow incremental methodology. U.S. Fish and Wildlife Service, Instream Flow Information Paper No. 12, FWS/OBS-82/26.

Brechtl, S.H. 1981. The White Pelicans, Double-crested Cormorants and Great Blue Herons in Alberta, 1980. Unpubl. Rept. Alta. Ener. and Nat. Res. Fish and Wildl. Div.

Burt, D.W. and J.H. Mundie. 1986. Case histories of regulated stream flow and its effects on salmonid populations. Can. Tech. Rep. Fish. Aquat. Sci. No. 1477. Department of Fisheries and Oceans, Vancouver.

Call, M. 1978. Nesting habitats and surveying techniques for common western raptors. U.S. Dept. Int. Bur. Land Mange., Denver, Co. Tech. Note TN-316. 115 pp.

Canada/United States Steering Committee. 1986. North American waterfowl management plan, May 1986. Canadian Wildlife Service, Ottawa and U.S. Fish and Wildlife Serv., Washington. 19 pp.

Canada-Saskatchewan, SSRBS. 1986. Study Proposal for the South Saskatchewan River Basin in Saskatchewan. South Saskatchewan River basin Study, Moose Jaw, Saskatchewan.

Canadian Wildlife Service. 1979. Migratory Bird Habitat Priorities - Prairie Provinces. Habitat Management Section, Western and Northern Region. 104 pp.

Collias, N.E. and E.C. Collias. 1963. Selective feeding by wild ducklings of different species. Wilson Bull. 75: 6-14.

COSEWIC. 1990. Committee on the status of endangered wildlife in Canada.

Cranna, M.D. and J.S. Rowe. 1974. Natural Areas in Saskatchewan. National Research Council International Biological Programme - Conservation Terrestrial Summation Report-Saskatchewan Natural Area Survey. Unpubl. Rep., Saskatchewan Environment, Regina. 111 pp.

Dale, D. 1986. Land tenure of areas critical to Piping Plovers in Saskatchewan. Prep. for the Saskatchewan Natural History Society.

Dannell, K. and K. Sjoberg. 1977. Seasonal emergence of chironomids in relation to egglaying and hatching of ducks in a restored lake (Northern Sweden). Wildfowl 28: 129-135.

Duebbert, H.F., J.T. Lokemoen and D.E. Sharp. 1983. Concentrated nesting of mallards and gadwalls on Miller Lake Island, North Dakota. J. Wildl. Manage. 47: 729-740.

Duebbert, H.F. and J.T. Lokemoen. 1976. Ducks nesting in fields of undisturbed grass-legume cover. J. Wildl. Manage. 40:39-49.

Dwernychuk, L.W. and D.A. Boag. 1973. Effects of herbicide-induced changes in vegetation on nesting ducks. Can. Field Nat. 87: 155-165.

Dwyer, T.J., G.L. Krapu and D.M. Janke. 1979. Use of prairie pothole habitat by breeding mallards. J. Wildl. Manage. 43:526-531.

Ebert, J.I., E.L. Camilli and L. Wandsnider. 1989. Reservoir Bank Erosion and Cultural Resources: Experiments in Mapping and Predicting the Erosion of Archaeological Sediments at Reservoirs Along the Middle Missouri River with Sequential Historical Aerial Photographs. Contract Report EL-89-3. Prepared for Department of the Army, Army Corps of Engineers, Washington, D.C.

Environment Canada. 1989. Draft federal policy on wetland conservation and highlights of draft implementation plan: discussion paper. pp 5.

Environmental Conservation Service Task Force. 1981. Ecological Land Survey Guidelines for Environmental Impact analysis. Ecol. Land Class. Series, No.13, Lands Directorate, Environment Canada, Ottawa, 42 pp.

Fuller, T.K. and L.B. Keith. 1980. Summer ranges, cover-type use and denning of black bears near Fort McMurray, Alberta. Can. Field-Nat. 94:80-83.

Garrison, E.G. 1977. Modelling Inundation Effects for Planning and Prediction. In, Conservation Archaeology, A Guide for Cultural Resource Management Studies, ed. by M.B. Schiffer and G.J. Gumerman, pp. 151-157. Academic Press, New York.

Germann, C. and M. Thomas. 1988. Report on ARMS 1987 Heritage Resource Impact Assessment/Mitigation Activities. Permit 87-12. pp. 39-40. Report on file, Resource Centre, Saskatchewan Parks, Recreation and Culture, Regina.

Gilmer, D.S., R.E. Kirby, I.J. Ball and J.H. Reichman. 1977. Post-breeding activities of mallards and wood ducks in north central Minnesota. J. Wildl. Manage. 41: 345-359.

Godfrey, W.E. 1986. The birds of Canada. Natl. Mus. of Canada.

Gollop, M. 1990. Letter to South Saskatchewan River Basin Study office. Prep. by Sask. Parks and Ren. Res.

Gore, J.A. and G.E. Petts (eds). 1989. Alternatives in regulated river management. CRC Press, Inc. Boca Raton, Florida.

Gullion, G.W. 1970. Factors influencing ruffed grouse populations. Trans. N. Am. Wildl. and Nat. Res. Conf. 35:93-105.

Gullion, G.W. 1977. Forest manipulation for ruffed grouse. Trans. N. Am. Wildl. and Nat. Res. Conf. 42:449-458.

Haig, S.M. and L.W. Oring. 1985. Distribution and status of the Piping Plover throughout the annual cycle. J. Field Ornith. 56:334-345.

Harris, W., G. Wapple, R. Wapple, K. DeSmet and S. Lamont. 1985. Saskatchewan Piping Plovers 1984. Tech. Rept. to Saskatchewan Natural History Society and Saskatchewan Parks and Renewable Resources.

Harris, W.C. and S.M. Lamont. 1985. Saskatchewan Burrowing Owls: breeding distribution and habitat utilization. Prep. for Saskatchewan Natural History Society. Prep. by Prairie Environmental Services Incorporated.

Harris, W.C., A. Kabzems, A.L. Kosowan, G.A. Padbury and J.S. Rowe. 1983. Ecological regions of Saskatchewan. Tech. Bull. No. 10, Sask. Parks and Renewable Resources, Forestry Div., Prince Albert.

Hart, R.T. and H.M. Hunt. 1980. Terrestrial wildlife habitat inventory of the Prelate (72k) map area. Sask. Dept. of Tour. and Renew. Res., Wildl. Tech. Rept. 80-7. 186 pp. and illustr.

Hart, R.T. and H.M. Hunt. 1981. Terrestrial wildlife habitat inventory of the St. Walburg (72-F) map area. Sask. Dept. Tour and Renew. Res., Wildl. Tech, Rep. 81-14. 196 pp.

Hart, R.T. and S.R. Barber. 1979. Terrestrial wildlife habitat inventory of the Kindersley (72) map sheet area. Sask. Dept. Tour. and Renew. Res. Wildl. Tech. Rept. 79-5. 174 pp

Haug, E.A. and L.W. Oliphant. 1990. Movements, activity patterns, and habitat use of Burrowing Owls in Saskatchewan. J. Wildl. Manage. 54: 27-35.

Herrero, S. 1985. Bear attacks. Their causes and avoidance. Winchester Pres. Piscataway, N.J. 287 pp.

Herriott, T. 1989. Operation Burrowing Owl. Canadian Geographic. April/May 1989 :63-68.

Hilderman, Witty, Crosby, Hanna and Associates. 1983. Lake Diefenbaker Recreation Strategy: Background Report. Prepared for Parks and Lands Branch, Saskatchewan Parks and Renewable Resources, Regina, Saskatchewan.

Hjertaas, D. 1990. Unpublished computer print-out of Saskatchewan's Burrowing Owl nest sites for the period 1987-1989. Saskatchewan Parks and Renewable Resources, Regina.

Hochbaum, H.A. 1955. Travels and traditions of waterfowl. University of Minnesota Press, Minneapolis. 315 pp.

Houston, C.S. 1982. Artificial nesting platforms for Ferruginous Hawks. Blue Jay 40:208-213.

Houston, C.S. 1989. Twenty year trends in breeding densities and reproductive success of Ferruginous Hawks on community pastures in Saskatchewan. Presented at the Prairie Conservation and Endangered Species Workshop, Regina, January 29.

Houston, C.S. and M.J. Bechard. 1984. Decline of the Ferruginous in Saskatchewan. Am. Birds 38: 166-170.

Hudson, M.S. 1983. Waterfowl production on three age classes of stock ponds in Montana. J. Wildl. Manage. 47: 112-117.

Hunt, H.M. 1974. Habitat relations and reproductive ecology of Hungarian Partridge in a hedgerow complex. Wildlife Report No. 3, Saskatchewan Department of Tourism and Renewable Resources.

Hunt, H.M. 1981. The ecology and status of elk in Saskatchewan. Sask. Dept. Tour. and Renew. Resour., Wildl. Tech. Rep. 81-1. 69 pp.

J.D. Mollard and Associates Limited. 1984. Bank Erosion and Slumping Re-evaluation, Lake Diefenbaker - 1984. Submitted to Saskatchewan Environment. Report on file, Saskatchewan Water Corporation, Moose Jaw.

James, P.C. and G.A. Fox. 1987. Effects of some insecticides on productivity of Burrowing Owls. Blue Jay 45: 65-69.

Jasikoff, T.M. 1982. Habitat suitability index models: Ferruginous Hawk. FWS/OBS-82/10.10. U.S. Fish and Wildlife Service.

Johnsgard, P.A. 1975. North American game birds of upland and shoreline. Univ. of Nebraska Press, Lincoln. 183 pp.

Johnson, E. 1988. Archaeological Monitoring and Collection at the Coteau Pasture sites (EgNq-7 and 8) and Aitkow Besant Complex (EgNp-58, 59, 63, 75) on Lake Diefenbaker, South-Central Saskatchewan. Submitted to SPRC, Heritage Branch, Permit 87-10. Report on file, Resource Centre, Saskatchewan Parks, Recreation and Culture, Regina.

Joyner, D.E. 1980. Influence of invertebrates on pond selection by ducks in Ontario. J. Wildl. Manage. 44: 700-705.

Kaminski, R.M. and H.H. Prince. 1981. Dabbling duck and aquatic macro-invertebrate responses to manipulated wetland habitat. J. Wildl. Manage. 45: 1-15.

Kantrud, H.A. and R.E. Stewart. 1984. Ecological distributions and crude density of breeding birds on prairie wetlands. J. Wildl. Manage. 48: 426-437.

Kortegaard, L. 1974. An ecological outline of a moulting area of teal. Vejlerne, Denmark. Wildfowl 25: 134-142.

Kramer, A. 1972. A review of ecological relationships between mule and white-tailed deer. Alta. Dept. Lands and Forests. Fish and Wildl. Div. Occ. Paper No. 3. 54 pp.

Krapu, G.L. and G.A. Swanson. 1975. Some nutritional aspects of reproduction in prairie nesting pintails. J. Wildl. Manage. 39: 156-162.

La Roi, G.H., T.A. Babb, C.E. Perley, and P.R. Mortimer (eds.). 1979. Canadian National Directory of IBP Areas. 3rd Ed. Univ. Alberta Printing Service, Edmonton.

Lamb, B.L. and H.R. Doerksen. 1987. Instream water use. Pp.109-116 In: National Water Summary 1987 - Water Supply and Use: Hydrologic Perspectives On Water Use. U.S. Geol. Sur. Water-supply Paper 2350.

Le Resche, R.E., R.H. Bishop and J.W. Coady. 1974. Distribution and habitats of moose in Alaska. Naturaliste. Can. 101: 143-176.

Leitch, W.G. 1964. Water. Pages 273-281 In J.P. Linduska (ed.). Waterfowl tomorrow. U.S. Dep. Interior, Fish and Wildlife Service, Washington, D.C. 770 pp.

Lenihan, D.J. and T. Carrell, S. Fosberg, L. Murphy, S. Rayl and J. Ware. 1977. The Final Report of the National Reservoir Inundation Study, Vol. 1. U.S. Dept. of the Interior, National Park Service, Santa Fe.

Linduska, J.P. 1964. Waterfowl tomorrow. U.S. Dept. Inter. Fish and Wildlife Service. Washington.

Lokemoen, J.T. 1973. Waterfowl production on stock watering ponds in the Northern plains. J. Range Manage. 26: 179-184.

Lokemoen, J. and A. Kruse. 1977. Populations and habitats of the Hungarian partridge in eastern North Dakota. In Proc. Perdix I, Hungarian partridge workshop. Minot, North Dakota.

MacFarlane, R. 1990. Unpublished Ducks Unlimited project files.

MacLennan, R. 1973. A study of waterfowl crop depredation in Saskatchewan. Sask. Dept. Nat. Res. Wildl. Rept. No. 2. 38 pp.

Martinka, C.J. 1968. Habitat relationships of white-tailed and mule deer in northern Montana. J. Wildl. Manage. 32: 558-565.

Mathewson, C.C. (compiler). 1989. Interdisciplinary Workshop on the Physical-Chemical-Biological Processes Affecting Archaeological Sites. Contract Report EL-89-1. Prepared for Department of the Army, Army Corps of Engineering, Washington, D.C.

Millenium Heritage Resource Consultants Ltd. 1989. SaskEnergy 1989 Gas Distribution Program, Heritage Resources Impact Assessment. Submitted to SPRC, Heritage Branch, Permit #89-31. Report on file, Resource Centre, Saskatchewan Parks, Recreation and Culture, Regina, Saskatchewan.

Millsap, B.A., K.W. Cline and B.D. Giron Pendleton. 1987. Habitat management - Chapter 12. pp 215-237. In: Millsap, B.A., K.W. Cline, B.A. Giron Pendleton and D.M. Bird (eds.). Raptor management techniques manual. Natl. Wildl. Fed. Washington.

Moyles, D.L.J. 1981. Seasonal and daily use of plant communities by Sharp-tailed Grouse (Pedioecetes phasianellus) in the parklands in Alberta. Can. Field-Nat. 95:287-291.

NAWMP. 1989. Saskatchewan Implementation Strategy - Prairie Habitat Joint Venture. 21 pp.

NAWMP. n.d. Prairie Habitat: A Prospectus - Prairie Habitat Joint Venture. 32 pp.

Nietfeld, M., J. Wilk, K. Woolnough, and B. Hoskin. 1984. Wildlife habitat requirements summaries for selected wildlife species in Alberta. Alberta Fish and Wildlife Division, Edmonton.

Olendorff, R.R. 1973. The ecology of the nesting birds of prey of northeastern Colorado. Grassland biome ecosystem analysis studies. U.S. International Biological Program. Tech. Rept. No. 211. Colorado State University, Fort Collins .

Oring, L.W. 1964. Behaviour and ecology of certain ducks during the post-breeding period. J. Wildl. Manage. 28: 223-233.

Pepper, G.W. 1972. The ecology of sharp-tailed grouse during spring and summer in the aspen parklands of Saskatchewan. Sask. Dept. Nat. Res., Wildl. Rep. #1. 56 pp.

Petts, G.E. 1984. Impounded rivers. John Wiley & Sons, Chichester.

Poston, B., D.M. Ealey, P.S. Taylor and G.B. McKeating. 1990. Priority Migratory Bird Habitats of Canada's Prairie Provinces. Canadian Wildlife Service. Edmonton. 107 pp.

Prose, B.L. 1987. Habitat suitability index models: Sharp-tailed Grouse. Biol. Rept. 82 (10.142). United States Fish and Wildlife Service.

Reed, E.B. 1962. Limnology and fisheries of the Saskatchewan River in Saskatchewan. Fisheries Branch Report No. 6. Dept. Nat. Res.

Renaud, W.E. 1979. The Piping Plover in Saskatchewan : a status report. Blue Jay 37 : 116.

Risser, R.J. and R.R. Harris. 1989. Mitigation for impacts to riparian vegetation on western montane streams. Pp. 235-250 In: Alternatives in Regulated River Management. J.A. Gore and G.E. Petts (eds). CRC Press, Inc. Boca Raton, Florida.

Rogers, L.L. and A.W. Allen. 1987. Habitat suitability index models: black bear, upper Great Lakes region. 82 (10.144). United States Fish and Wildlife Service.

Roney, K. 1978. Pelicans, cormorants and Great Blue Herons in Saskatchewan in 1976. Blue Jay 36: 28-35.

Rue, L.L. III. 1981. Furbearing animals of North America. Crown Publishers, Inc., New York, New York. 343 pp.

Rusch, D.H., M.M. Gillespie and D.I. McKay. 1978. Decline of a Ruffed Grouse population in Manitoba. Can. Field-Nat. 92: 123-127.

Rusch, D.H., M.M. Gillespie and D.I. McKay. 1971. Seasonal and annual trends in numbers of Alberta Ruffed Grouse. J. Wildl. Manage. 35: 803-822.

Salomonsen, F. 1968. The moult migration. Wildfowl 19: 5-24. Saskatchewan Department of Natural Resources. 1966. Resource Reader. Regina, Saskatchewan.

Salt, W.R. and J.R. Salt. 1976. The birds of Alberta. Hurtig Publishers. Edmonton.

Sankowski, T.P., K.L. Schmitt, S.J. Guinn, G.R. Stewart and R.B. Burns (1987). "The Kitsim Complex, an Example of a Small Wetland Development Benefitting Waterfowl and Cattle Production" in C.D.A. Rubec and R.P. Overend (eds.), Proceedings, Symposium '87, Wetlands/Peatlands, Edmonton, Alberta, August 23-27.

Savage, A. and C. Savage. 1981. Wild mammals of western Canada. Western Producer Prairie Books, Saskatoon, Saskatchewan. 209 pp.

Schmutz, J.K. 1982. An estimate of Ferruginous Hawks in Alberta and the relationship between their density and land use. A report for the Alberta Environmental Research Trust and the Fish and Wildlife Division of Alberta Energy and Natural Resources.

Schmutz, J.K. 1984. Ferruginous and Swainson's Hawk abundance and distribution in relation to land use in southeastern Alberta. J. Wildl. Manage. 48:1180-1187.

Schmutz, J.K. 1987. The effect of agriculture on Ferruginous and Swainson's Hawks. J. Range Manage. 40: 438-440.

Schmutz, J.K. 1989a. Management plan for the Ferruginous Hawk. Prep. for Wild West Steering Committee, World Wildlife Fund Canada.

Schmutz, J.K. 1989b. Hawk occupancy of disturbed grasslands in relation to models of habitat selection. Condor 91: 362-371.

Schmutz, J.K., R.W. Fyfe, D.A. Moore and A.R. Smith. 1984. Artificial nests for Ferruginous and Swainson's Hawks. J. Wildl. Manage. 48: 1009-1013.

Sherratt, D. and G. Kerr. 1990. November 19, 1990 letter to South Saskatchewan River Basin Study Office. Prep. by Sask. Parks and Ren. Res. and Can. Wildl. Serv.

Smith, A. 1990. Unpublished computer print-out of Saskatchewan's Ferruginous Hawk nest sites for the period 1966-1989. Canadian Wildlife Service, Saskatoon.

Smith, A.G. 1969. Waterfowl - habitat relationships on the Louisiana, Alberta, waterfowl study area. Pages 116-122 In Saskatoon wetlands seminar. Can. Wildl. Service. Report Series No. 6.

Smith, A.R. 1987. Status of the Ferruginous Hawk in Saskatchewan. pp. 199-203. In : Holroyd et al. (eds.). Proceedings of the workshop on endangered species in the prairie provinces. Prov. Museum of Alberta Occ. Pap. No. 9.

Soper, J.D. 1964. The mammals of Alberta. Queen's Printer, Edmonton. 402 pp.

Sousa, P. 1981. Prairie Falcon: habitat suitability index model for the Price River - Book Cliffs study areas. Western Ener. and Land Use Team. U.S. Dept. Inter. Fish and Wildl. Serv. Washington. 13 pp.

Stalnaker, C.B., and J.L. Arnette (eds). 1976. Methodologies for the determination of stream resource flow requirements: an assessment. Prepared for U.S. Fish and Wildlife Service, Office of Biological Services, Western Water Allocation. Prepared by Utah State University, Logan.

Stanford, J.V. and J.V. Ward. 1979. Stream regulation in North America. Pp.215-235 In: The Ecology Of Regulated Rivers. J.V. Ward and J.A. Stanford (eds). Plenum Press, New York.

Stewart, R.E. and H.A. Kantrud. 1973. Ecological distributions of breeding waterfowl populations in North Dakota. J. Wildl. Manage. 37: 39-50.

Stewart, R.R. 1981. Seasonal diets of white-tailed deer in three broad ecological zones in Saskatchewan. Sask. Dept. Tour. and Renew. Resour., Wildl. Tech. Rep. 81-4. 21 pp.

Strong Hall & Associates, Marv Anderson and Associates Limited and Environmental Management Associates. 1984. South Saskatchewan River basin planning program: evaluation methodologies and data base. Prep. of Alberta Environment.

Sugden, L. 1973. Feeding ecology of Pintail, Gadwall, American Wigeon and Lesser Scaup ducklings. Can. Wildl. Serv. Rep. Ser. No. 24. 45 pp.

Swenson, J.E., S.J. Knapp and H.J. Wentland. 1983. Winter distribution and habitat use by mule deer and white-tailed deer in southeastern Montana. Prairie Nat. 15: 97-112.

Task Force on Soil, Water and Wetlands Management in Saskatchewan. 1990. Report prep. for Government of Saskatchewan Minister responsible for Saskatchewan Water Corporation.

Turner, B.C., G.S. Hochbaum, F.D. Caswell and D.J. Nieman. 1987. Agricultural impacts on wetland habitats on the Canadian prairies, 1981-1985. Trans. N. Amer. Wildl. Nat. Res. Conf. 52: 206-215.

Vermeer, K. 1973. Great Blue Heron and Double-crested Cormorant colonies in the prairie provinces. Can. Field-Nat. 83: 427-432.

Voigts, D.K. 1976. Aquatic invertebrate abundance in relation to changing marsh vegetation. Amer. Midl. Nat. 95: 313-322.

Wallmo, O.C. 1981. Mule deer and black-tailed deer of North America. Wildl. Manage. Inst. and U.S. Dept. Agric. and For. Serv. Univ. of Nebraska Press. Lincoln and London. 605 pp.

Ward, J.V. 1976. Effects of flow patterns below large dams on stream benthos. Pp.235-252 In: Instream Flow Needs, Vol.II. J.F.Osborne and C.H. Allman (eds). American Fisheries Society, Bethesda, Maryland.

Ward, J.V. and J.A. Stanford (eds). 1979. The ecology of regulated streams. Plenum Press, New York.

Wedgwood, J.A. 1978. The status of the Burrowing Owl in Canada. Prep. for the Committee On the Status of Endangered Wildlife in Canada. Prep. under contract to the Canadian Wildlife Service.

Welch, E.B. 1980. Ecological effects of waste water. Cambridge University Press, Cambridge.

Weller, M.W. and L.H. Fredrickson. 1974. Avian ecology of a managed glacial marsh. Living Bird 12: 269-291.

Yoakum, J. 1974. Pronghorn habitat requirements for sagebrush-grassland. Antelope States Workshop Proc. 6: 16-25.

Young, D.A. 1989. A discussion paper on soil, water and wetlands. Prep. for Prov. of Sask. Prep. by Environmental Management Associates. 117 pp.

Young, D.A. and J.P. Thompson. 1990. Wetlands are not wastelands - prairie pothole pilot study. Prep. for Sustainable Development State of Environment Reporting Branch, Canadian Wildlife Service, and Wildlife Habitat Canada. Prep. by Environmental Management Associates and Thompson Economic Consulting Services.

Young, D.A., M.A. Weber and D.S. Kerr. 1984a. Investigations of wildlife along canals in the Eastern and Taber Irrigation Districts, southern Alberta. Vol. 1, Waterfowl. Prep. for Alberta Environment, Planning Division. Prep. by Environmental Management Associates.

Young, D.A., M.A. Weber and D.S. Kerr 1984b. Investigations of wildlife along canals in the Eastern and Taber Irrigation Districts, southern Alberta. Vol. 2, Ring-necked Pheasants and Gray Partridge. Prep. for Alberta Environment, Planning Division. Prep. by Environmental Management Associates.

Young, D.A., M.A. Weber and D.S. Kerr. 1984c. An investigation of Ring-necked Pheasant ecology during winter in southern Alberta. Prep. for Alberta Fish and Wildlife Division. Prep. by Environmental Management Associates.

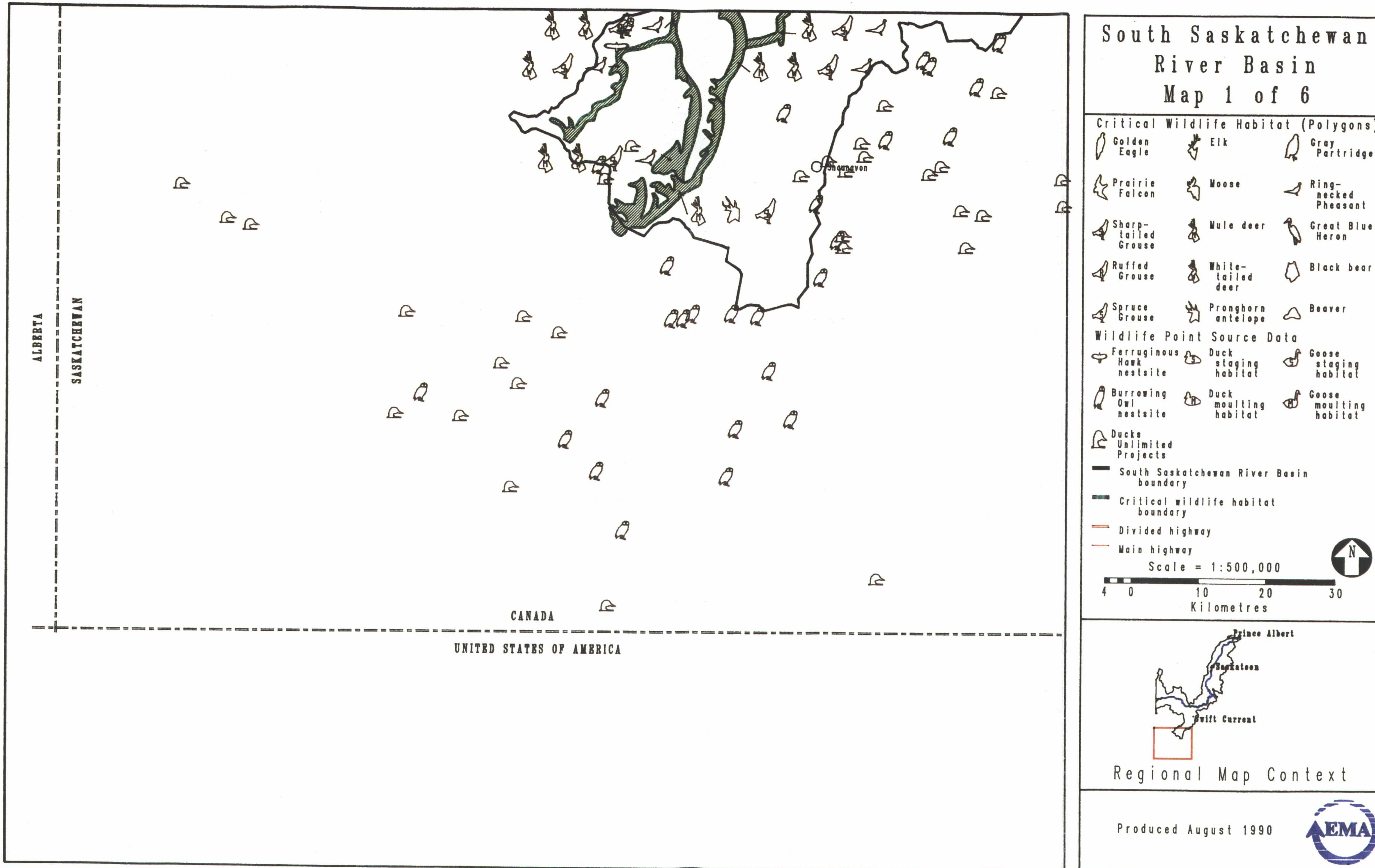
Zarn, M. 1974. Habitat management series for unique or endangered species - Burrowing Owl. Rept. No. 11. U.S. Bureau of Land Management, Denver, Colorado. 25 pp.

APPENDIX A
SOUTH SASKATCHEWAN RIVER BASIN STUDY
LIST OF TECHNCIAL REPORTS

SOUTH SASKATCHEWAN RIVER BASIN STUDY TECHNICAL REPORTS		
TITLE	SSRB TECHNICAL REPORT	DATE
Annual Report to December 31, 1986	A.3	11.87
Annual Report to December 31, 1987	A.4	07.88
Annual Report to December 31, 1988	A.5	05.89
Annual Report to December 31, 1989	A.6	03.90
Compendium of Water Quality Objectives Development Methodologies	D.9	06.88
Contaminant Organic Compounds in the Surface Waters of the South Saskatchewan River Basin	D.4	12.87
Crop Damage and Associated Economic Impact of Flooding, South Saskatchewan River Downstream of Lake Diefenbaker	E.13	12.89
Data Collection and Date Base Development: South Saskatchewan River Basin Recreation Survey	E.1	11.86
The Delphi Report	B.3	08.90
Demand for Water-Based Recreation in the South Saskatchewan River Basin	E.17	08.90
Economic Profile and Trends 1951-1986	E.9	06.88
Erosion and Sedimentation in the South Saskatchewan River Basin	C.9	12.89
Farm-Level Drought Analysis Model	E.15	08.90
Fishery Survey of the South Saskatchewan River and Its Tributaries in Saskatchewan	D.8	11.88
Flood Frequencies in the South Saskatchewan River Basin	C.5	08.88
Flooding Gardiner Dam to the Forks	C.8	10.89
Framework Plan Working Definition	B.1	09.87
Frequency Analysis of Meterological Drought in the Saskatchewan Portion of the South Saskatchewan River Basin	C.4	07.88
Ground Water and the South Saskatchewan River Basin: Recommendations to the Study Board	C.2	03.88
Ground Water Study: South Saskatchewan River Basin	C.2	03.88
Heritage Resources	E.16	08.90
A Hydraulic Study of the South Saskatchewan River	E.12	05.89
Hydro System Simulation (HYDSIM) Model Study Report	C.7	05.89
Hydrologic Drought Analysis of Simulated Flows - South Saskatchewan River Basin	C.6	02.89
Information Base: Surface Water Hydrology and Water Use	E.2	03.87
Instream Water Use: South Saskatchewan River Basin	E.7	12.87
Irrigation Water Use Pilot Study	E.8	04.88
Irrigation Water Use Survey (South Saskatchewan River Basin Study)	E.11	12.88
Lake Diefenbaker Trophic State Model	D.5	01.88
Land Use in the Effective Drainage Area of the South Saskatchewan River Basin	D.2	10.87

SOUTH SASKATCHEWAN RIVER BASIN STUDY TECHNICAL REPORTS		
TITLE	SSRB TECHNICAL REPORT	DATE
Legal and Administrative Analysis Interim Report	B.2	03.88
Legal and Administrative Summary	B.4	02.91
Low Flow Frequency Analysis for the South Saskatchewan River	C.10	05.91
Major Industrial Water Users in the South Saskatchewan River Basin	E.10	10.88
Mass Loading of Phosphorus to Lake Diefenbaker	D.13	09.89
Municipal and Residential Water Use Study	E.5	08.87
Municipal Water Use Survey	E.3	07.87
Nutrient Quality Review and Objectives Development for the South Saskatchewan River Basin	D.14	01.90
Phosphorus Loading from Non-Point Sources Relevant to the Lake Diefenbaker Basin	D.1	09.87
Proposed Water Quality Objectives for the South Saskatchewan River Basin	D.12	08.89
Public Involvement Program Position Paper	F.1	10.86
Public Opinion Survey, 1988 Survey Design	F.2	03.88
Recreational Data Analysis Report South Saskatchewan River Basin	E.4	07.87
Reservoir Salinity Model: Application to the Saskatoon Southeast Water Supply System	D.16	05.90
Reservoir Salinity Study Phase 1	D.7	10.88
Short-term Water Use Forecast South Saskatchewan River Basin Study	E.14	12.89
Study Plan and Annual Work Plans - 1987	A.2	02.87
Study Proposal for the South Saskatchewan River Basin	A.1	04.86
Style Guides for Reports	A.7	03.90
Summary and Evaluation of the Public Information and Awareness Strategy	F.3	09.89
Summary and Evaluation of the Public Information and Awareness Strategy, April 1990	F.4	04.90
Summary and Evaluation of the Public Information and Awareness Strategy, November 1990	F.5	12.90
Water Demand Management: An Application to the South Saskatchewan River Basin	E.18	08.90
Water Intake and Outfall Survey South Saskatchewan River Basin	E.6	12.87
Water Management Model Study South Saskatchewan River Basin	C.1	01.88
Water Quality Data Review	D.6	03.88
Water Quality Modelling South Saskatchewan River	D.10	04.89
Water Quality Monitoring Plan for the South Saskatchewan River Basin	D.15	04.90
Water Quality Monitoring Review South Saskatchewan River Basin	D.11	06.89
Water Quality Trend Analysis and Data Base Summary	D.3	11.87
Water Use Analysis Model Study: South Saskatchewan River Basin Study	D.19	05.91

APPENDIX B
MAP PORTFOLIO


South Saskatchewan River Basin
Map 1 of 6
Critical Wildlife Habitat (Polygons)
Golden Eagle
Elk
Gray Partridge
Prairie Falcon
Moose
Ring-necked Pheasant
Sharp-tailed Grouse
Mule deer
Great Blue Heron
Ruffed Grouse
White-tailed deer
Black bear
Spruce Grouse
Pronghorn antelope
Beaver
Wildlife Point Source Data
Ferruginous Hawk nestsite
Duck staging habitat
Goose staging habitat
Burrowing Owl nestsite
Duck moulting habitat
Goose moulting habitat
Ducks Unlimited Projects
South Saskatchewan River Basin boundary
Critical wildlife habitat boundary
Divided highway
Main highway
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Scale = 1:500,000
4 0 10 20 30
Kilometres
Prince Albert
Saskatoon
Swift Current
Regional Map Context
Produced August 1990
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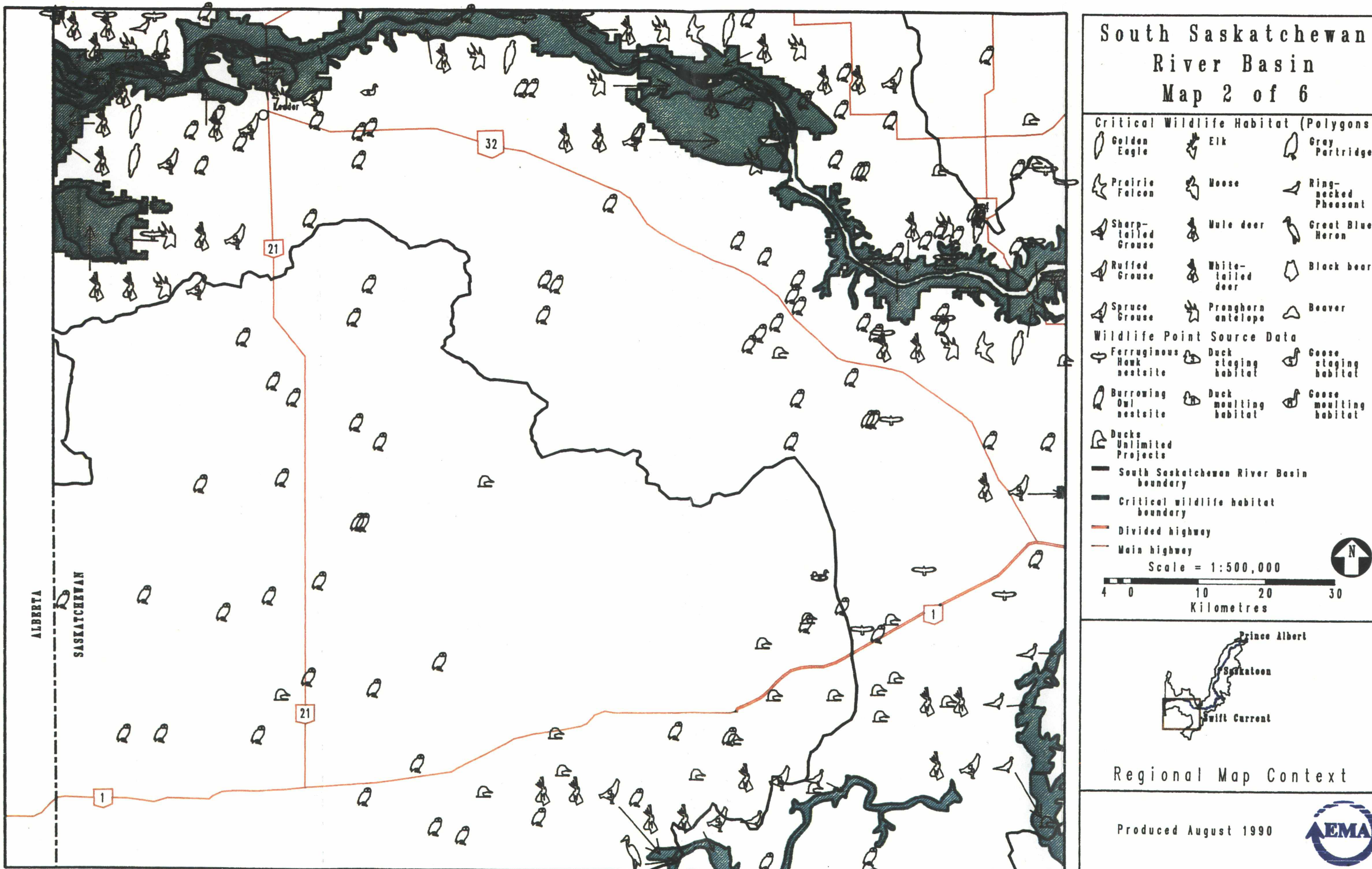
UNITED STATES OF AMERICA


South Saskatchewan River Basin
Map 2 of 6
Critical Wildlife Habitat (Polygons)
Golden Eagle
Elk
Gray Partridge
Prairie Falcon
Moose
Ring-necked Pheasant
Sharp-tailed Grouse
Mule deer
Great Blue Heron
Ruffed Grouse
White-tailed deer
Black bear
Spruce Grouse
Pronghorn antelope
Beaver
Wildlife Point Source Data
Ferruginous Hawk nestsite
Duck staging habitat
Goose staging habitat
Burrowing Owl nestsite
Duck moulting habitat
Goose moulting habitat
Ducks Unlimited Projects
South Saskatchewan River Basin boundary
Critical wildlife habitat boundary
Divided highway
Main highway
Scale = 1:500,000
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Prince Albert
Saskatoon
Swift Current
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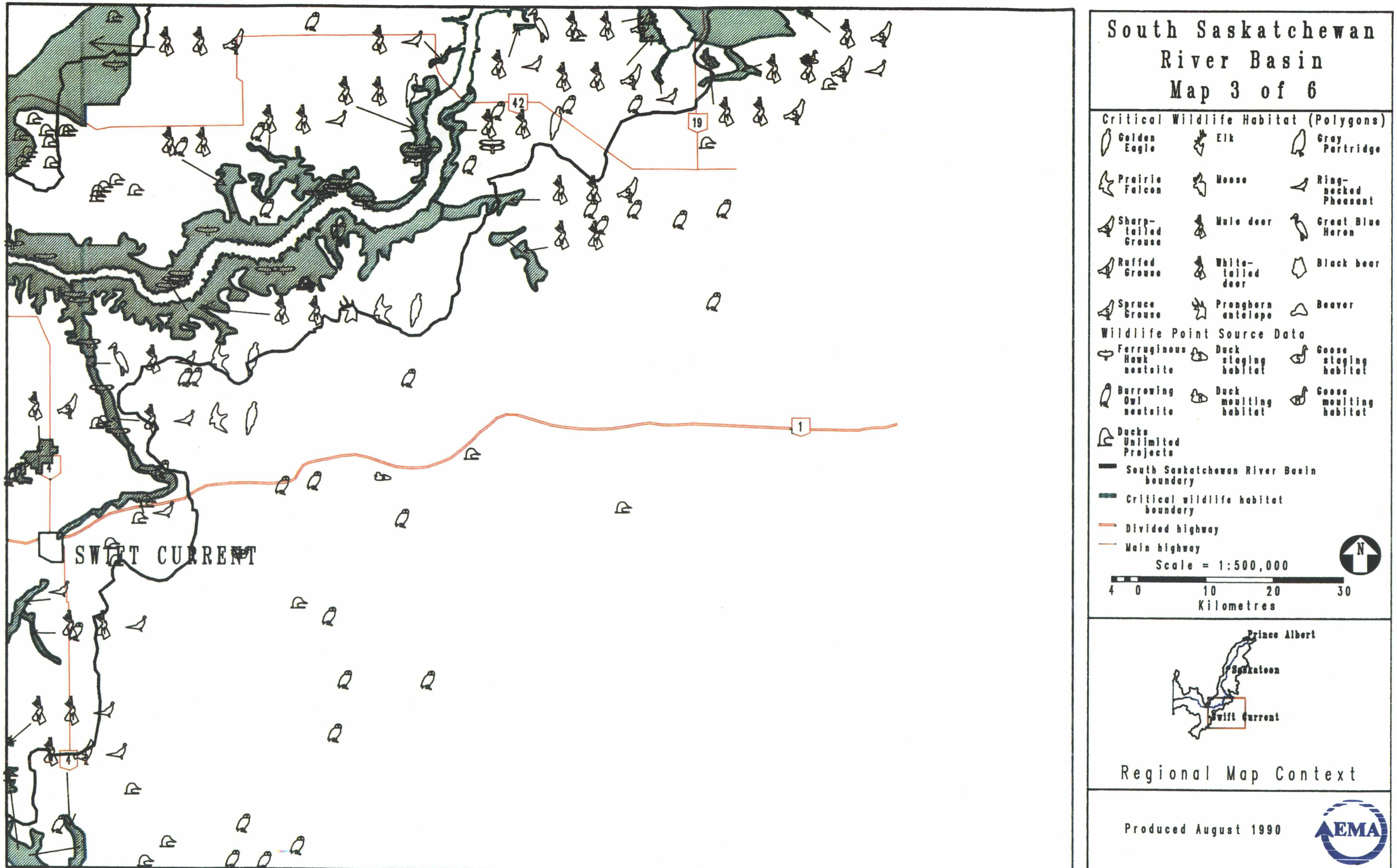
South Saskatchewan River Basin
Map 3 of 6
Critical Wildlife Habitat (Polygons)
Golden Eagle
Elk
Gray Partridge
Prairie Falcon
Moose
Ring-necked Pheasant
Sharp-tailed Grouse
Mule deer
Great Blue Heron
Ruffed Grouse
White-tailed deer
Black bear
Spruce Grouse
Pronghorn antelope
Beaver
Wildlife Point Source Data
Ferruginous Hawk nestsite
Duck staging habitat
Goose staging habitat
Burrowing Owl nestsite
Duck moulting habitat
Goose moulting habitat
Ducks Unlimited Projects
South Saskatchewan River Basin boundary
Critical wildlife habitat boundary
Divided highway
Main highway
Scale = 1:500,000
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Prince Albert
Saskatoon
Swift Current
Regional Map Context
Produced August 1990
EMA
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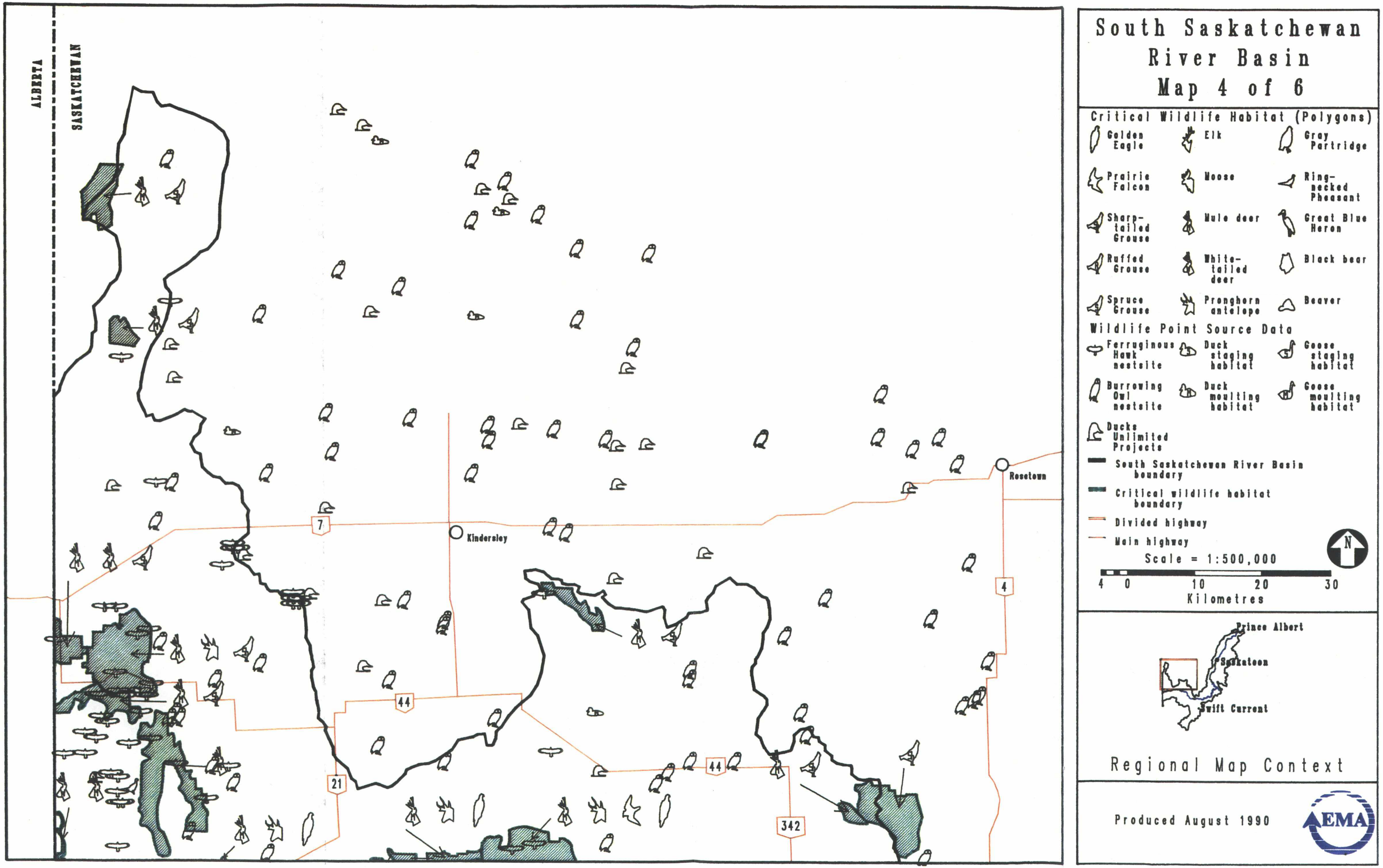
South Saskatchewan River Basin
Map 4 of 6
Critical Wildlife Habitat (Polygons)
Golden Eagle
Elk
Gray Partridge
Prairie Falcon
Moose
Ring-necked Pheasant
Sharp-tailed Grouse
Mule deer
Great Blue Heron
Ruffed Grouse
White-tailed deer
Black bear
Spruce Grouse
Pronghorn antelope
Beaver
Wildlife Point Source Data
Ferruginous Hawk nestsite
Duck staging habitat
Goose staging habitat
Burrowing Owl nestsite
Duck moulting habitat
Goose moulting habitat
Ducks Unlimited Projects
South Saskatchewan River Basin boundary
Critical wildlife habitat boundary
Divided highway
Main highway
Scale = 1:500,000
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Kilometres
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Prince Albert
Saskatoon
Swift Current
Regional Map Context
Produced August 1990
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SASKATCHEWAN
Kindersley
Rosetown
7
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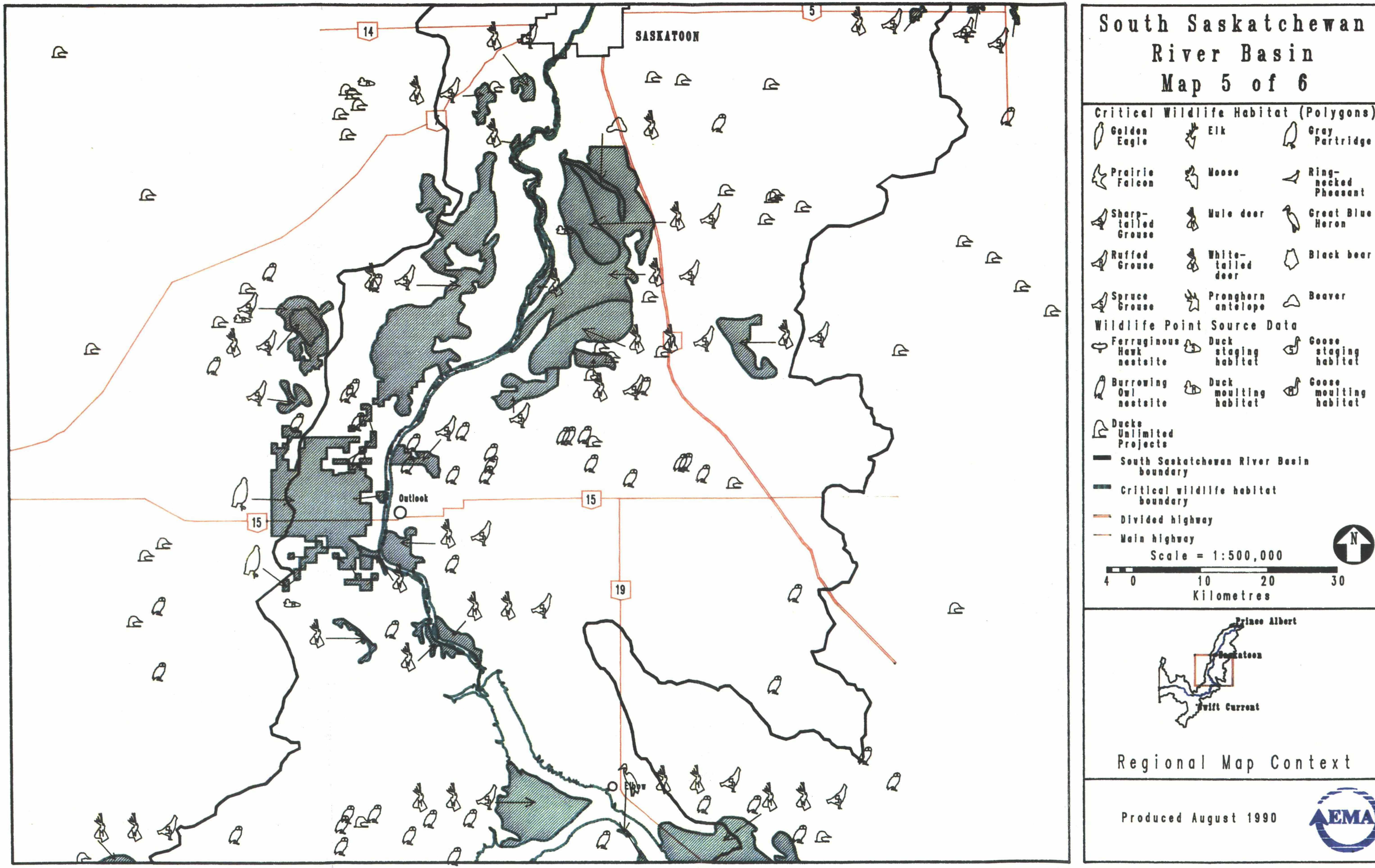
South Saskatchewan
River Basin
Map 5 of 6
Critical Wildlife Habitat (Polygons)
Golden Eagle
Elk
Gray Partridge
Prairie Falcon
Moose
Ring-necked Pheasant
Sharp-tailed Grouse
Mule deer
Great Blue Heron
Ruffed Grouse
White-tailed deer
Black bear
Spruce Grouse
Pronghorn antelope
Beaver
Wildlife Point Source Data
Ferruginous Hawk nestsite
Duck staging habitat
Goose staging habitat
Burrowing Owl nestsite
Duck moulting habitat
Goose moulting habitat
Ducks Unlimited Projects
South Saskatchewan River Basin boundary
Critical wildlife habitat boundary
Divided highway
Main highway
Scale = 1:500,000
4 0 10 20 30
Kilometres
N
Prince Albert
Saskatoon
Swift Current
Regional Map Context
Produced August 1990
SASKATOON
14
5
Outlook
15
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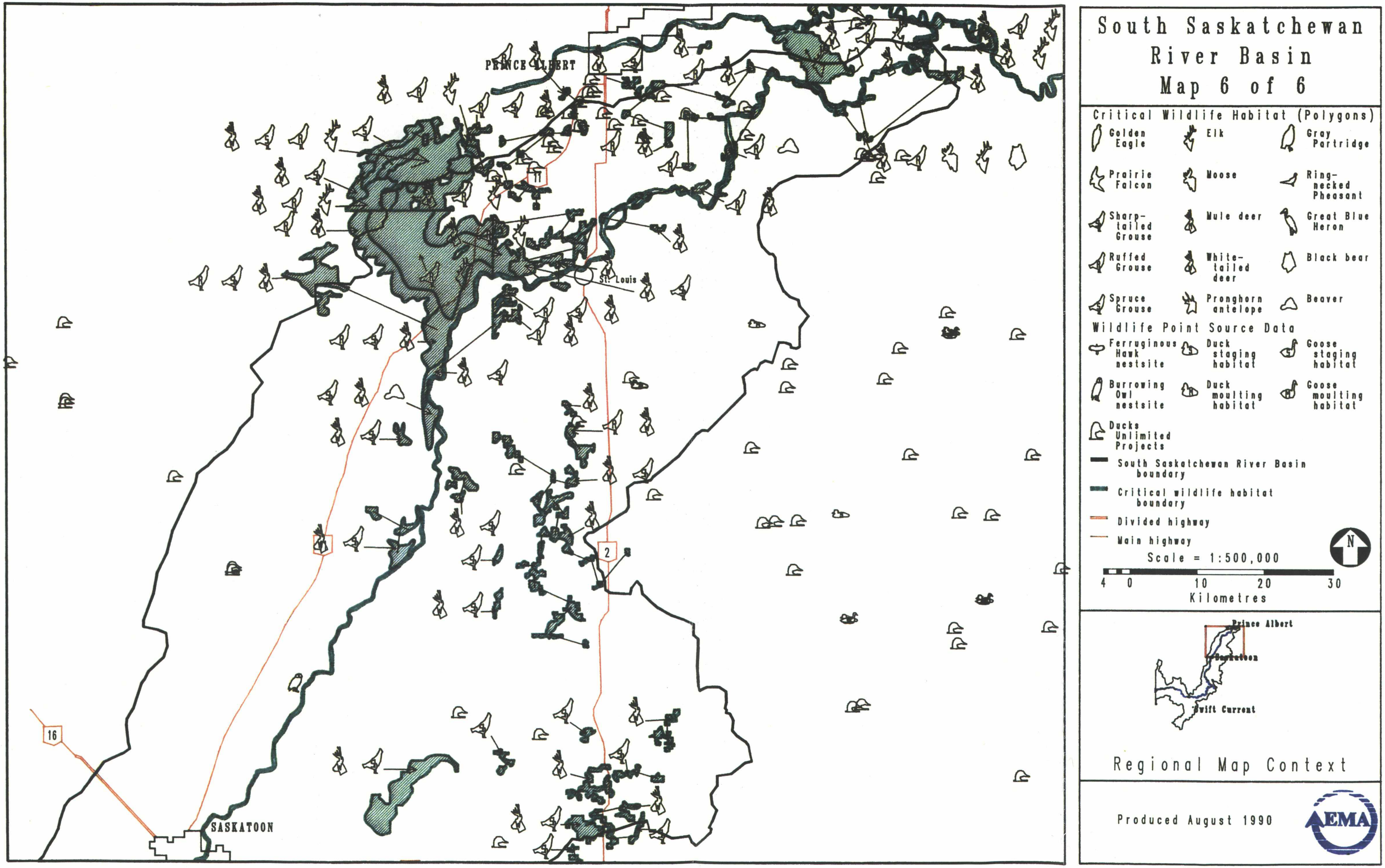
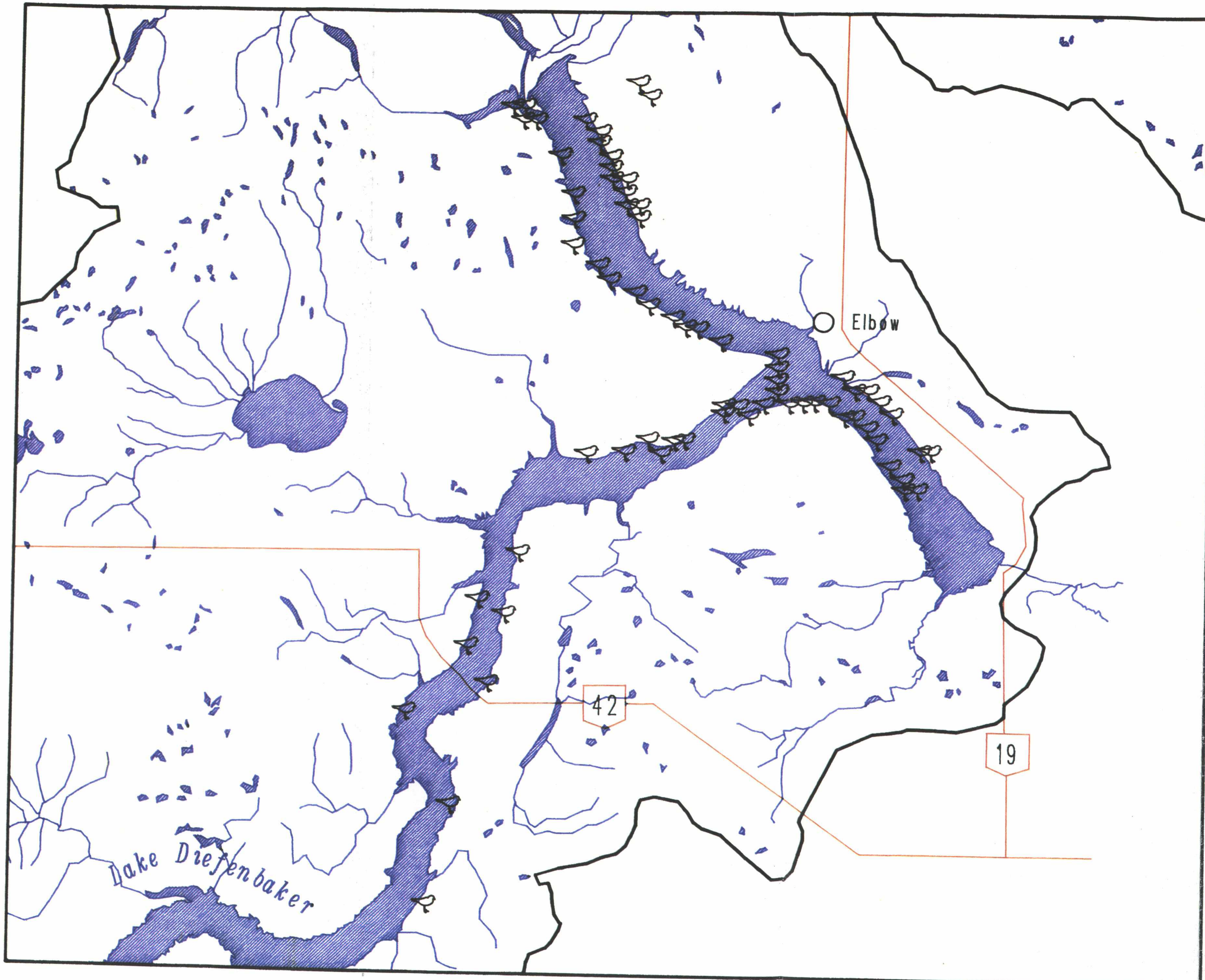


South Saskatchewan River Basin
Map 6 of 6
Critical Wildlife Habitat (Polygons)
Golden Eagle
Elk
Gray Partridge
Prairie Falcon
Moose
Ring-necked Pheasant
Sharp-tailed Grouse
Mule deer
Great Blue Heron
Ruffed Grouse
White-tailed deer
Black bear
Spruce Grouse
Pronghorn antelope
Beaver
Wildlife Point Source Data
Ferruginous Hawk nestsite
Duck staging habitat
Goose staging habitat
Burrowing Owl nestsite
Duck moulting habitat
Goose moulting habitat
Ducks Unlimited Projects
South Saskatchewan River Basin boundary
Critical wildlife habitat boundary
Divided highway
Main highway
Scale = 1:500,000
4 0 10 20 30
Kilometres
N
Prince Albert
Saskatoon
Swift Current
Regional Map Context
Produced August 1990
PRINCE ALBERT
St. Louis
SASKATOON
11
2
16

South Saskatchewan River Basin Piping Plover

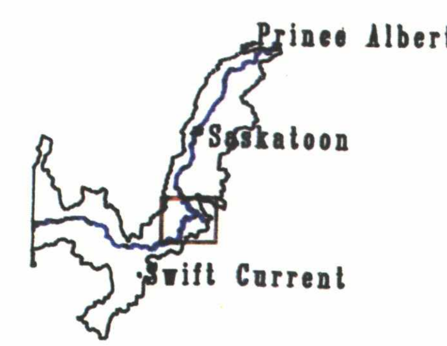


Territorial Plover Locations

- Piping Plover
- South Saskatchewan River Basin boundary
- Divided Highway
- Main Highway

Scale = 1:250,000

2 0 5 10 15
Kilometres

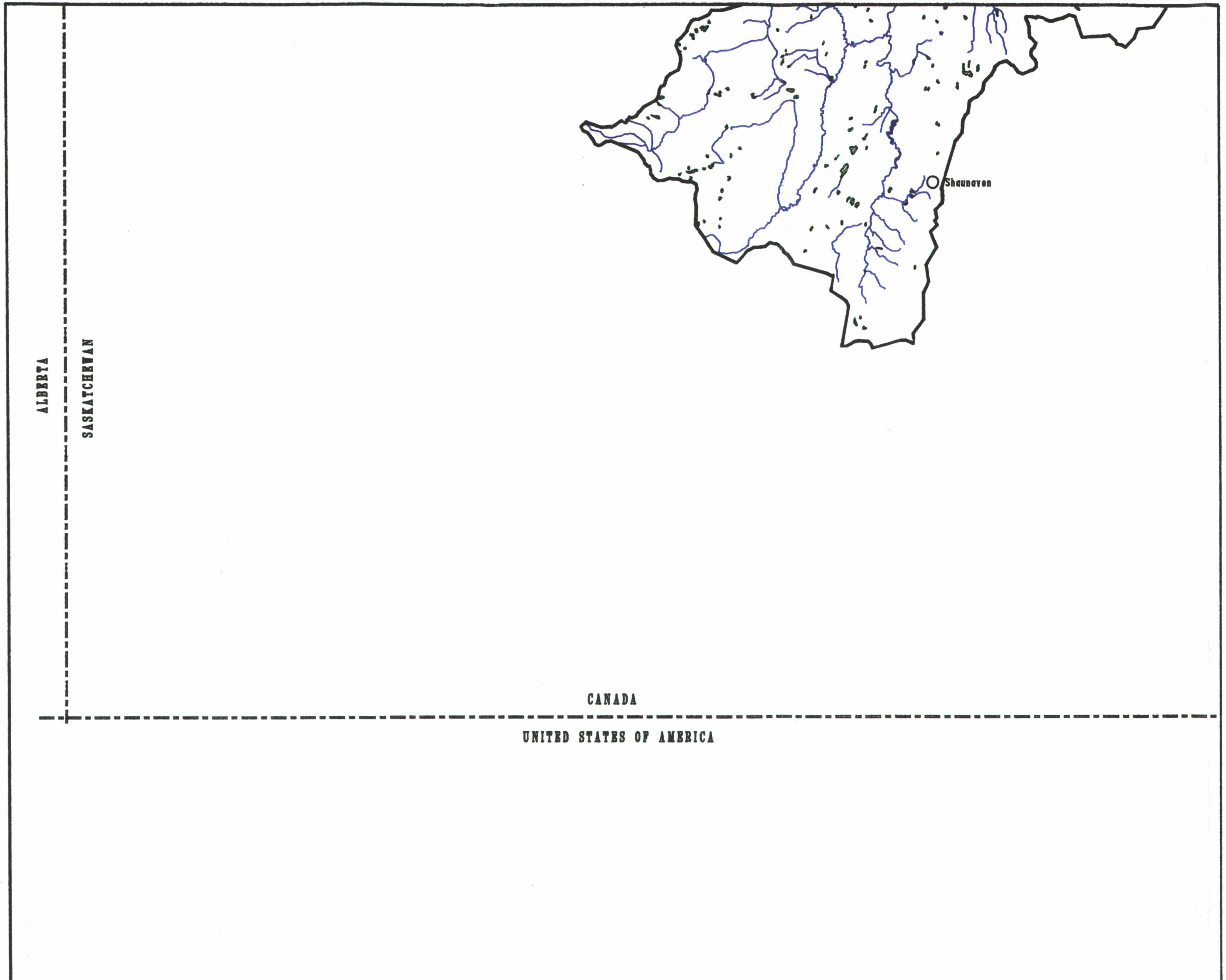


Regional Map Context

Produced September 1990

EMA

South Saskatchewan River Basin Map 1 of 6

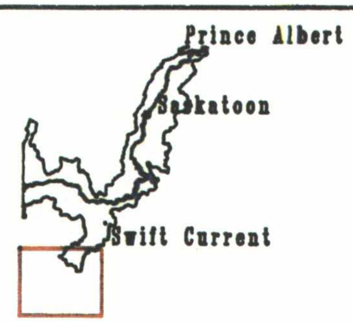


Wetland Legend

- Intermittent lakes, marsh
- Permanent lakes, river
- Creeks
- South Saskatchewan River Basin boundary
- Divided Highway
- Main Highway

Scale = 1:500,000

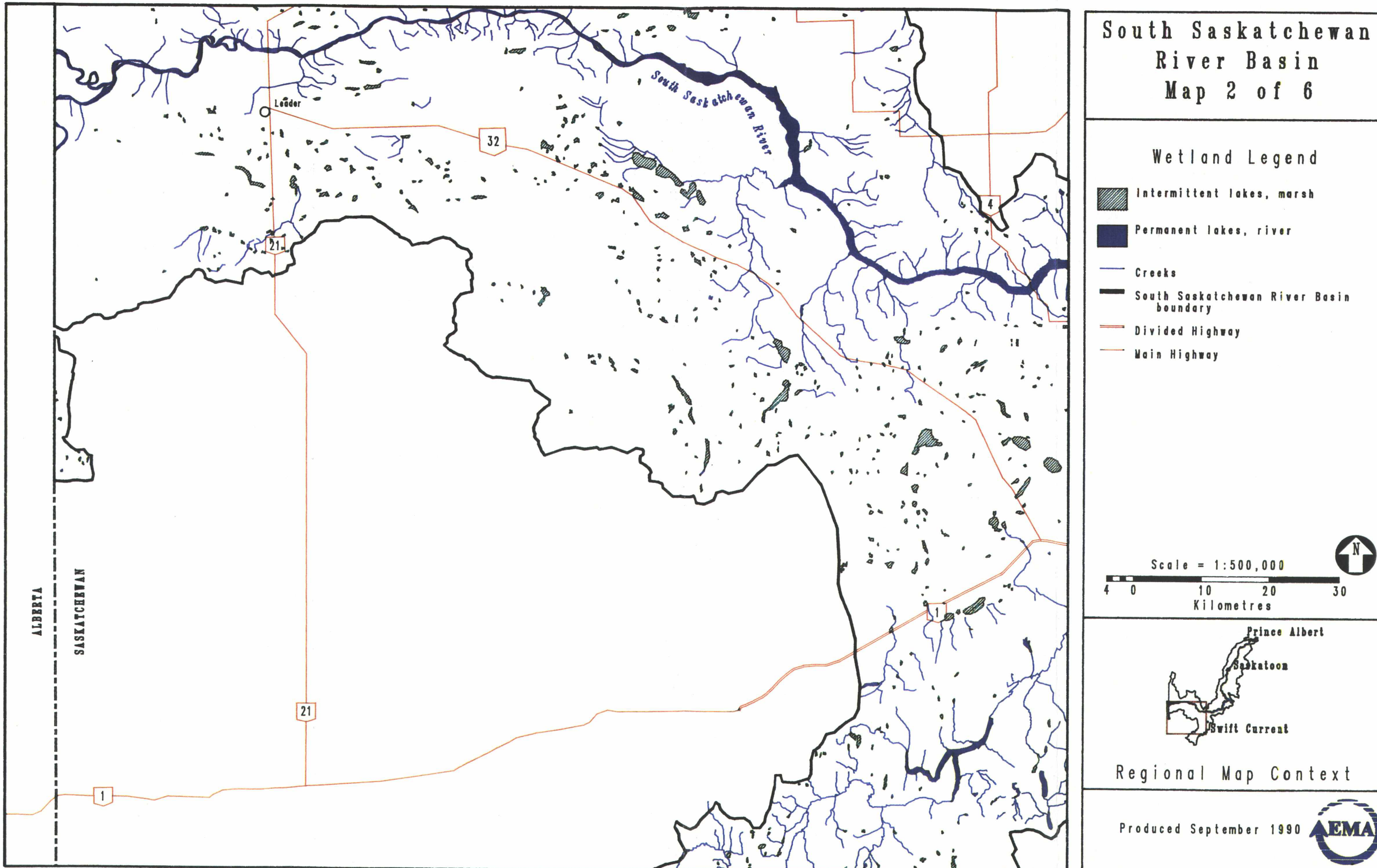
4 0 10 20 30
Kilometres

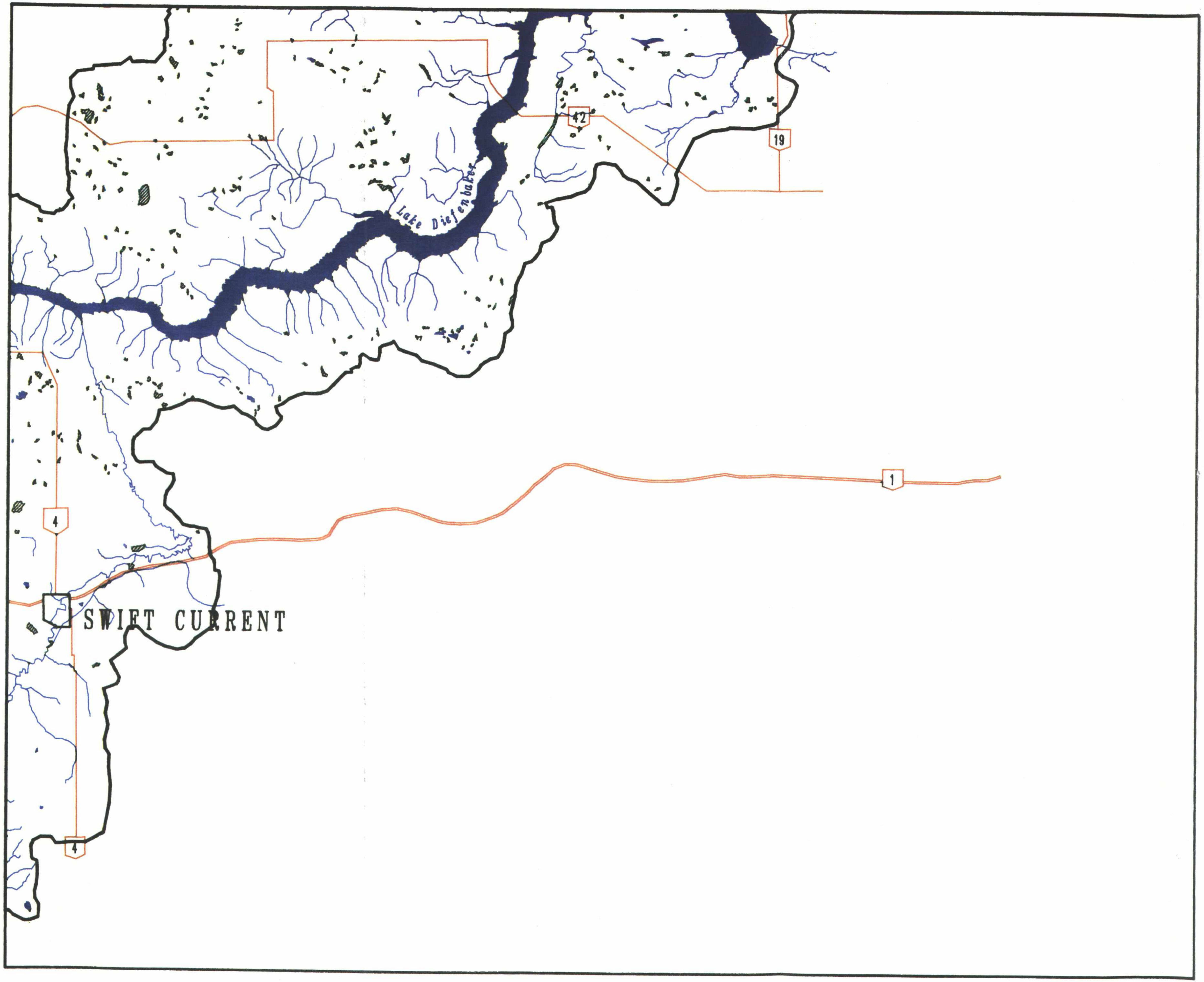


Regional Map Context

Produced September 1990

AEMA


South Saskatchewan River Basin
Map 2 of 6
Wetland Legend
Intermittent lakes, marsh
Permanent lakes, river
Creeks
South Saskatchewan River Basin boundary
Divided Highway
Main Highway
Scale = 1:500,000
4 0 10 20 30
Kilometres
N
Prince Albert
Saskatoon
Swift Current
Regional Map Context
Produced September 1990
South Saskatchewan River
Leader
32
21
4
1
ALBERTA
SASKATCHEWAN

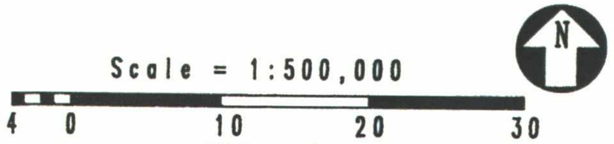


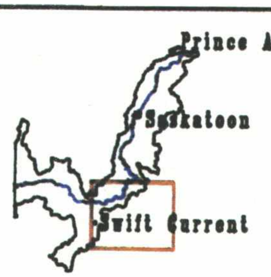
South Saskatchewan River Basin
Map 3 of 6

Wetland Legend

- Intermittent lakes, marsh
- Permanent lakes, river
- Creeks
- South Saskatchewan River Basin boundary
- Divided Highway
- Main Highway

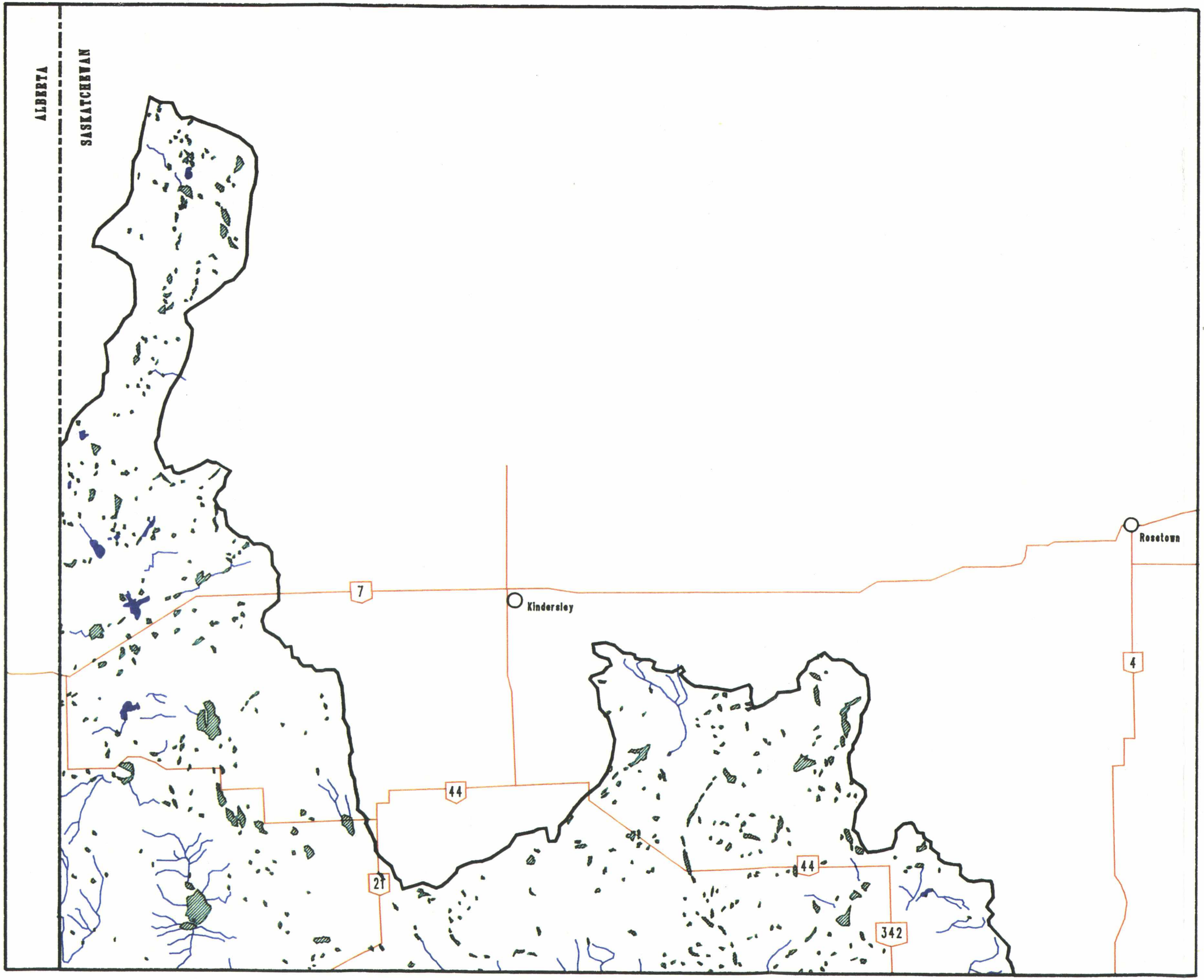
Scale = 1:500,000





Regional Map Context

Produced September 1990



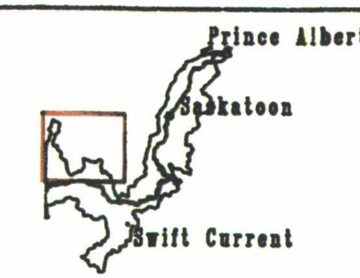
South Saskatchewan River Basin Map 4 of 6

Wetland Legend

- Intermittent lakes, marsh
- Permanent lakes, river
- Creeks
- South Saskatchewan River Basin boundary
- Divided Highway
- Main Highway

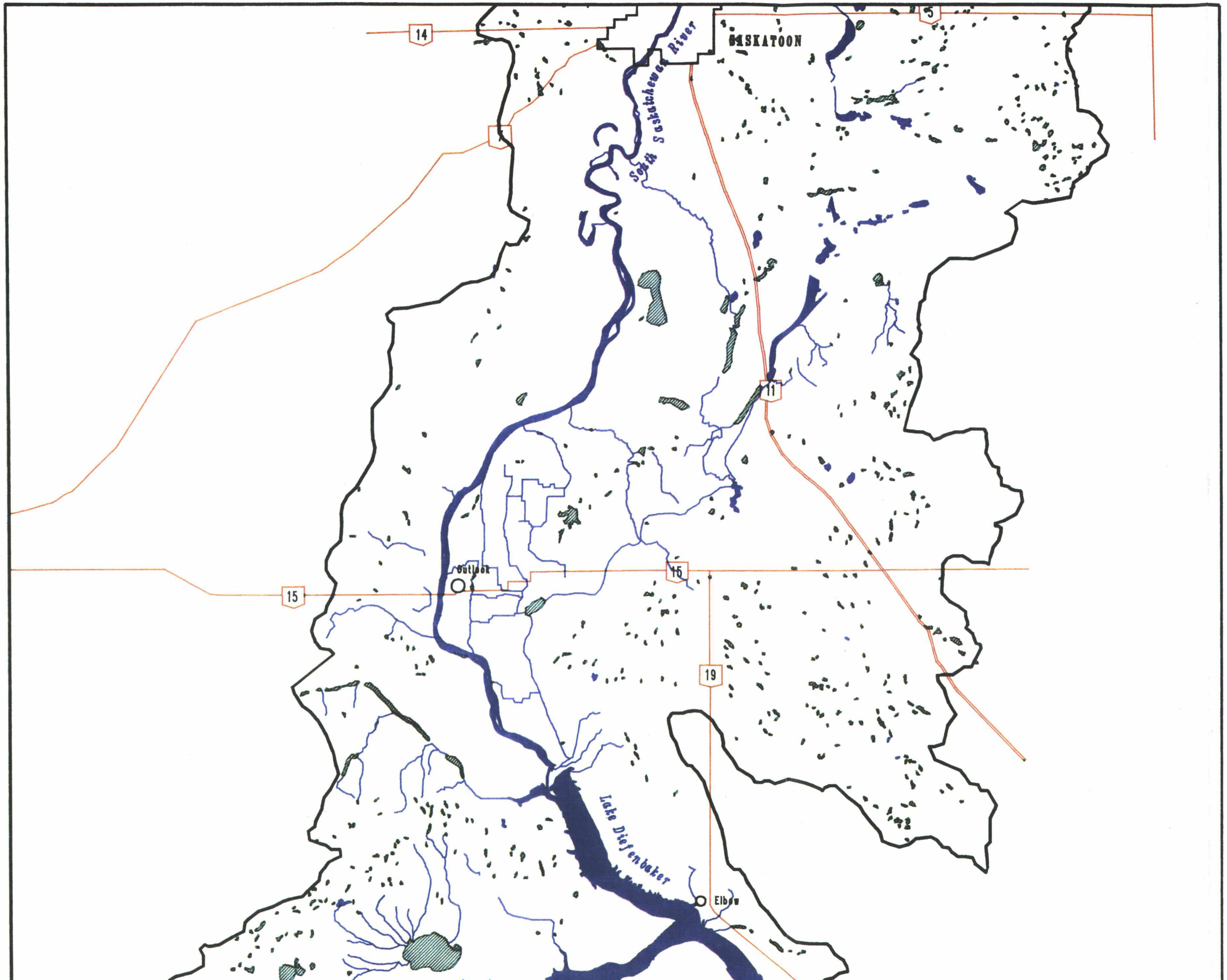
Scale = 1:500,000

4 0 10 20 30
Kilometres



Regional Map Context

Produced September 1990



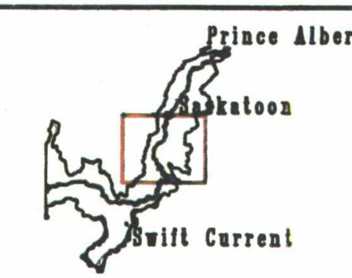
South Saskatchewan River Basin Map 5 of 6

Wetland Legend

- Intermittent lakes, marsh
- Permanent lakes, river
- Creeks
- South Saskatchewan River Basin boundary
- Divided Highway
- Main Highway

Scale = 1:500,000

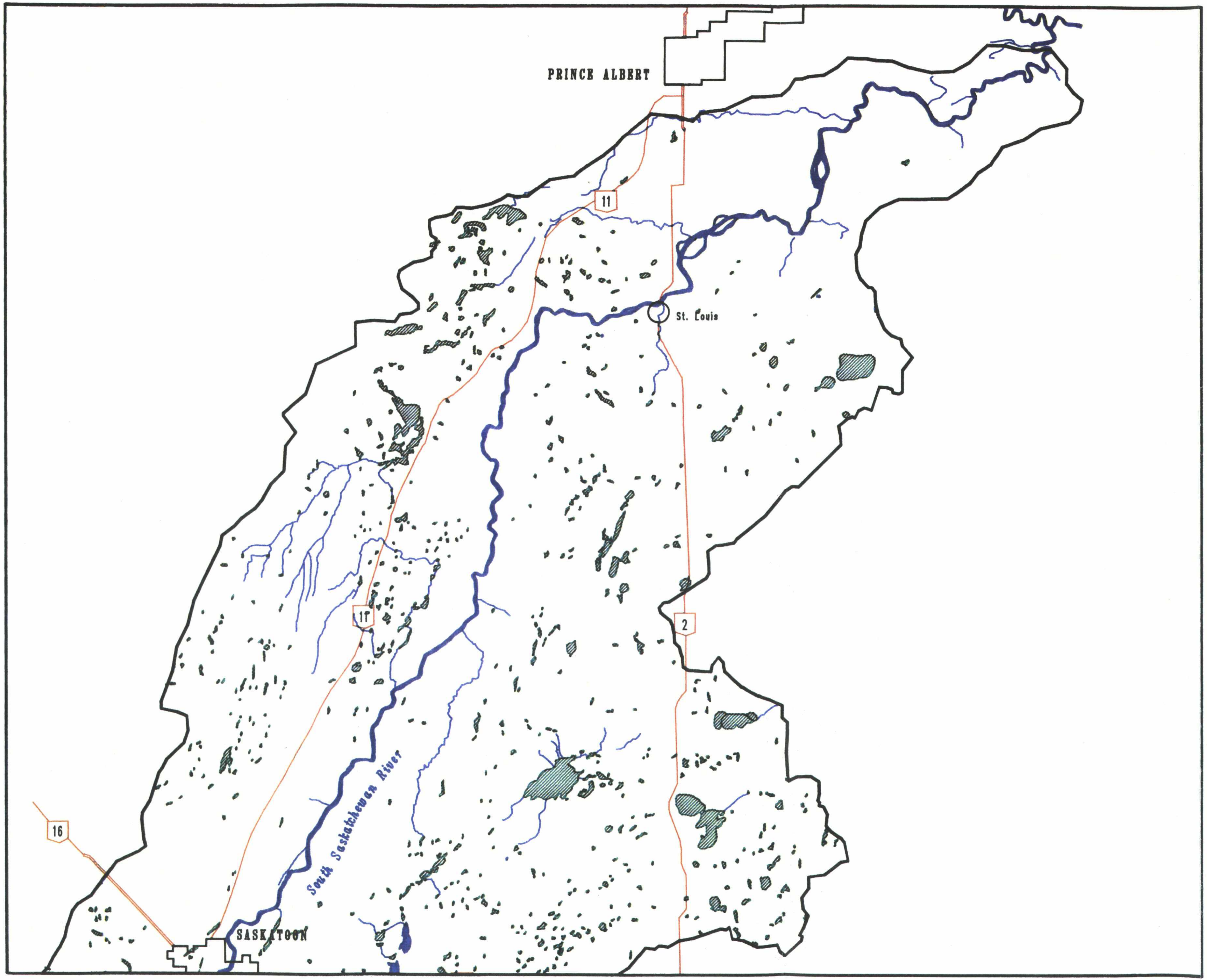
4 0 10 20 30
Kilometres



Regional Map Context

Produced September 1990

AEMA



South Saskatchewan River Basin Map 6 of 6

Wetland Legend

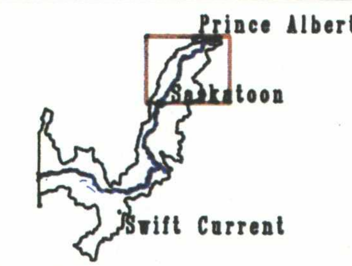
- Intermittent lakes, marsh
- Permanent lakes, river
- Creeks
- South Saskatchewan River Basin boundary
- Divided Highway
- Main Highway

Scale = 1:500,000

4 0 10 20 30

Kilometres

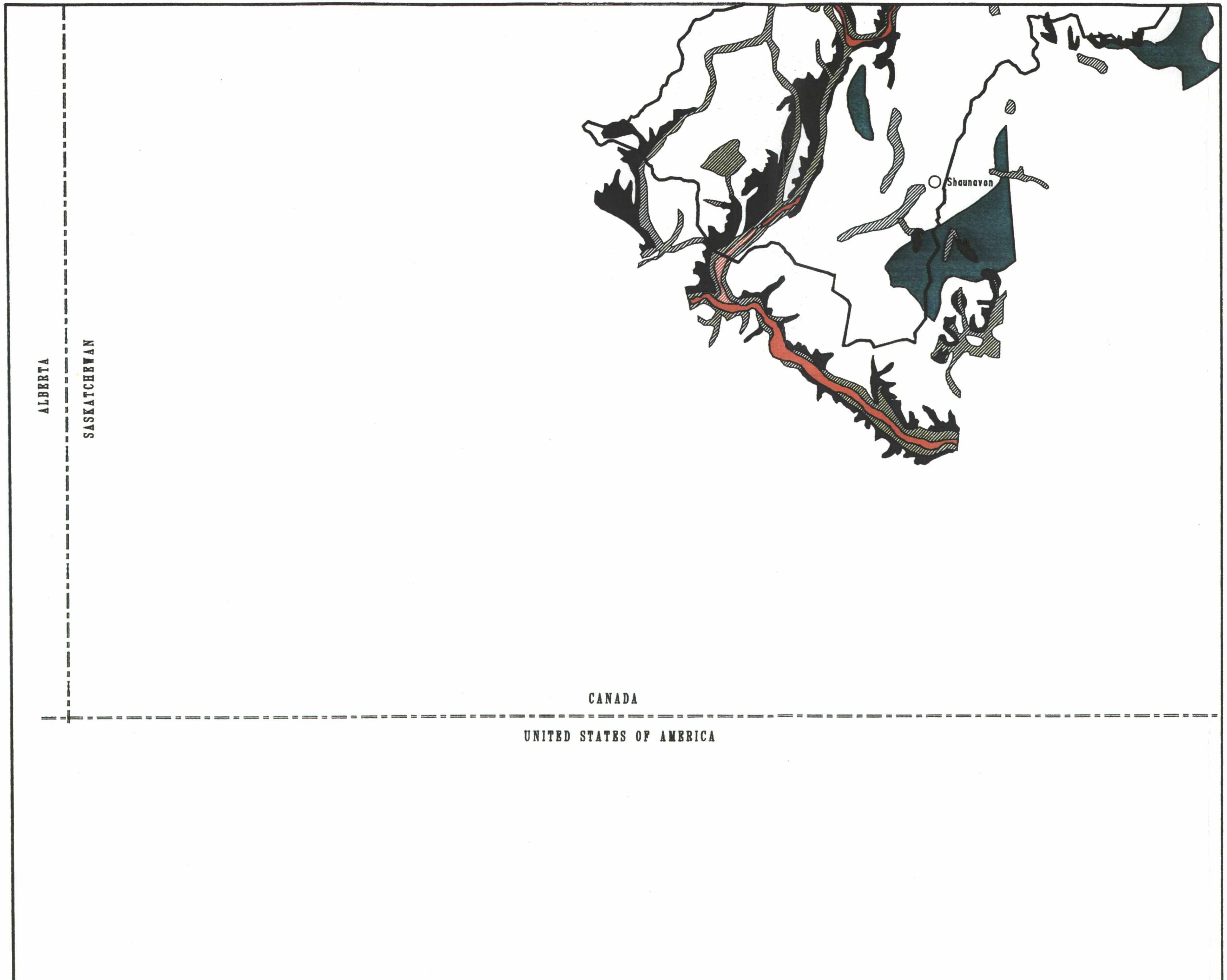
N



Regional Map Context

Produced September 1990

AEMA



South Saskatchewan River Basin
Map 1 of 6

ENVIRONMENTALLY SENSITIVE AREAS

Sensitive Terrain
- High relief, undulating to rolling topography
- Meltwater channels-moderately dissected slopes
- Gully complex-highly dissected slopes and tributaries

Sensitive Parent Material
- Aeolian-non stabilized, wind borne deposits
- Alluvium-fine textured, river borne sediments

Sensitive Drainage Features
- Active flood-plains and tributaries
- Organic wetland complex
- Organic fenland

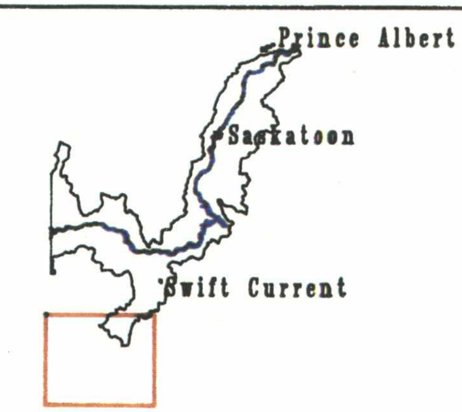
Sensitive Soils
- Predominantly saline soils
- Occasional saline soils
- Predominantly solonetzic (hardpan) soils
- Occasional solonetzic (hardpan) soils

- IBP / Natural Areas
- South Saskatchewan River Basin boundary
- Divided highway
- Main highway

N

Scale = 1:500,000

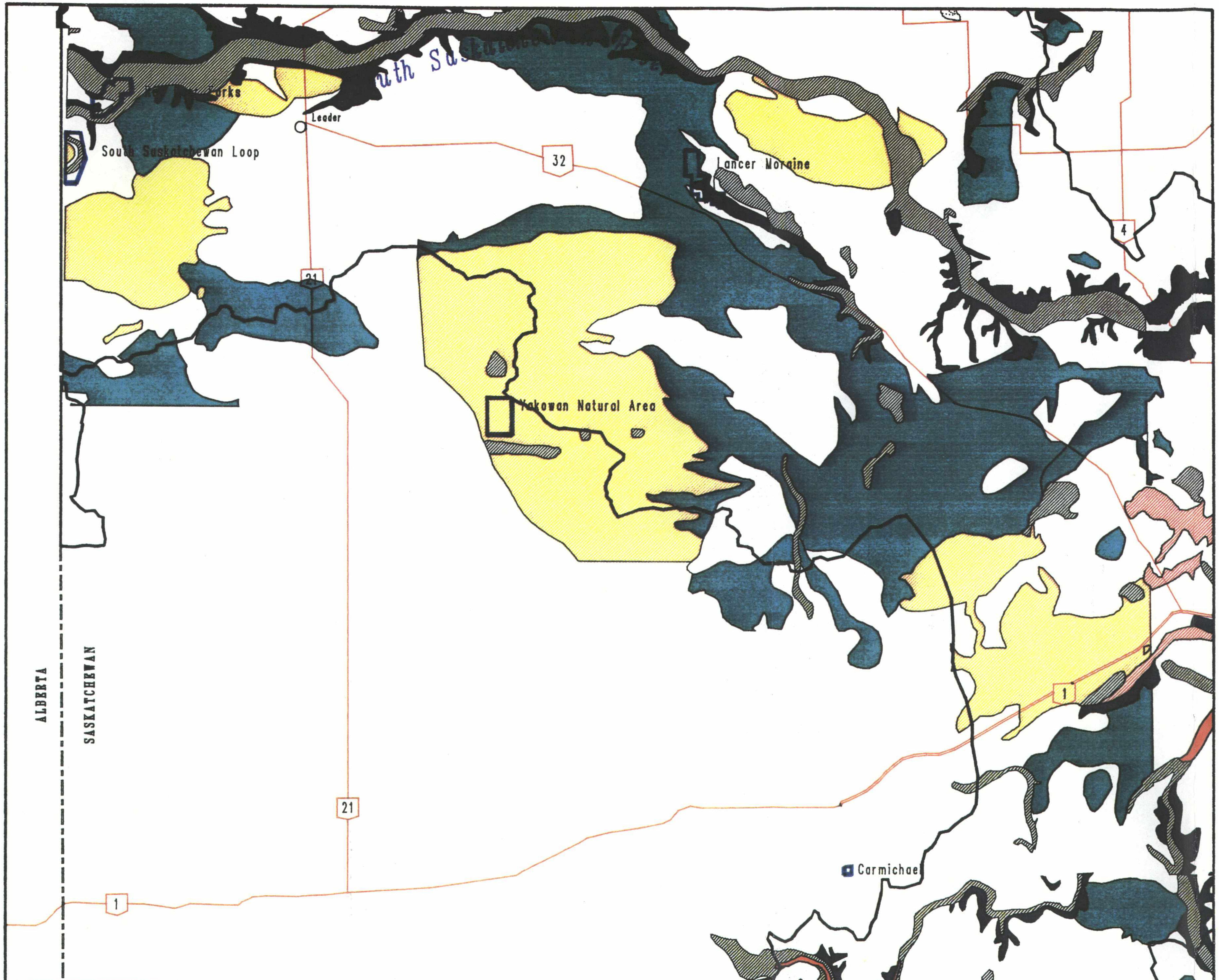
4 0 10 20 30
Kilometres



Regional Map Context

Produced August 1990

AEMA



South Saskatchewan River Basin Map 2 of 6

ENVIRONMENTALLY SENSITIVE AREAS

Sensitive Terrain
- High relief, undulating to rolling topography
- Meltwater channels- moderately dissected slopes
- Gully complex- highly dissected slopes and tributaries

Sensitive Parent Material
- Aeolian- non stabilized, wind borne deposits
- Alluvium- fine textured, river borne sediments

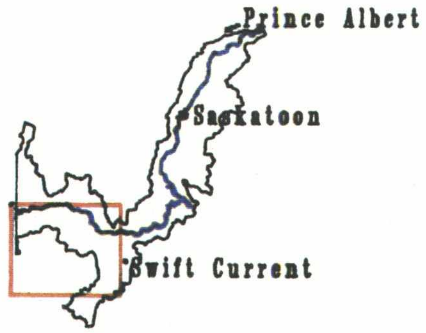
Sensitive Drainage Features
- Active flood- plains and tributaries
- Organic wetland complex
- Organic fenland

Sensitive Soils
- Predominantly saline soils
- Occasional saline soils
- Predominantly solonetzic (hardpan) soils
- Occasional solonetzic (hardpan) soils

- IBP / Natural Areas
- South Saskatchewan River Basin boundary
- Divided highway
- Main highway

Scale = 1:500,000

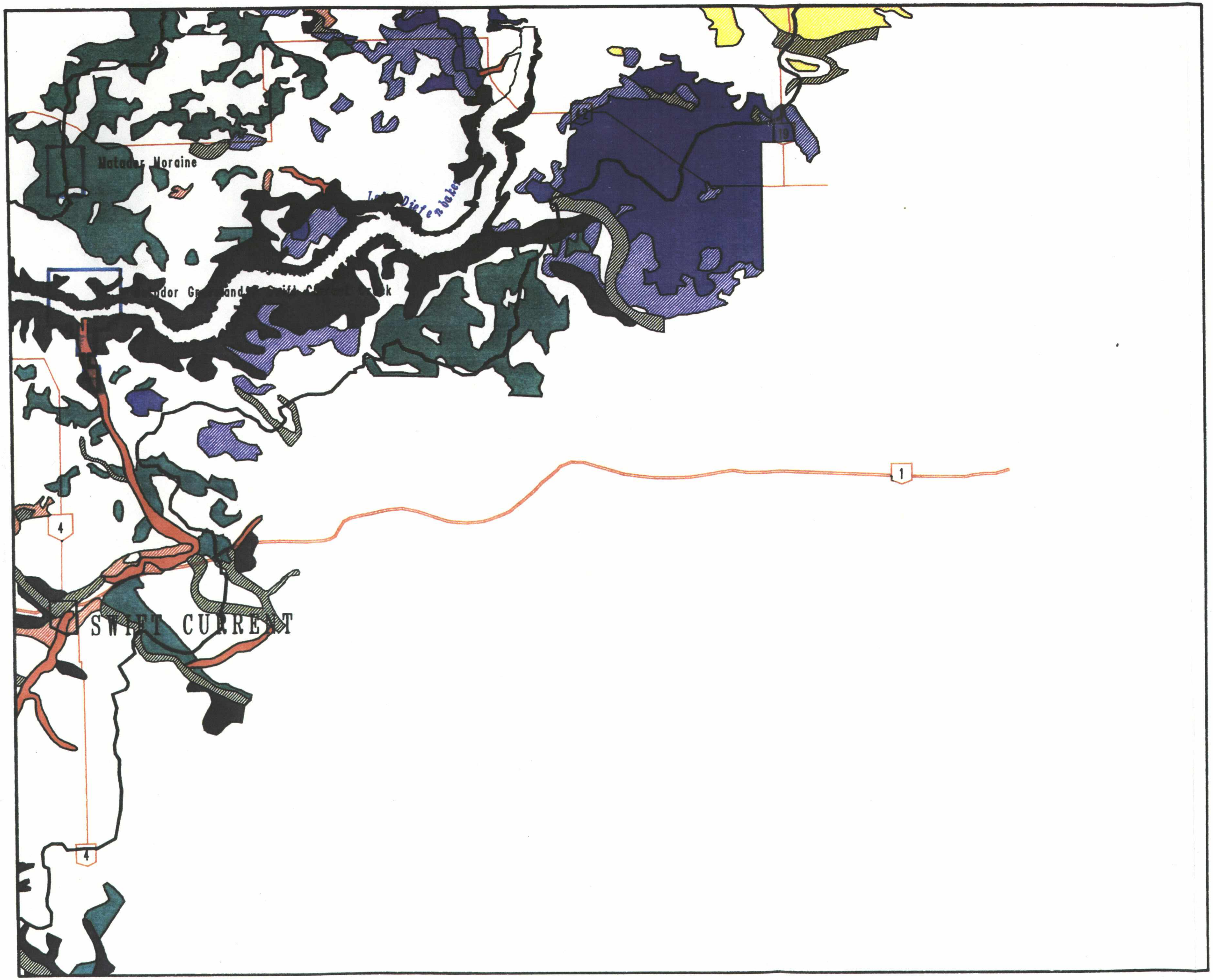
4 0 10 20 30
Kilometres



Regional Map Context

Produced August 1990

South Saskatchewan River Basin
Map 3 of 6



ENVIRONMENTALLY SENSITIVE AREAS

Sensitive Terrain
- High relief, undulating to rolling topography
- Meltwater channels-moderately dissected slopes
- Gully complex-highly dissected slopes and tributaries

Sensitive Parent Material
- Aeolian-non stabilized, wind borne deposits
- Alluvium-fine textured, river borne sediments

Sensitive Drainage Features
- Active flood-plains and tributaries
- Organic wetland complex
- Organic fenland

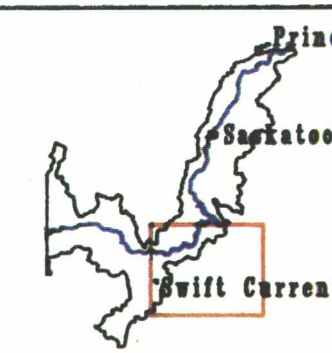
Sensitive Soils
- Predominantly saline soils
- Occasional saline soils
- Predominantly solonetzic (hardpan) soils
- Occasional solonetzic (hardpan) soils

- IBP / Natural Areas
- South Saskatchewan River Basin boundary
- Divided highway
- Main highway

N

Scale = 1:500,000

4 0 10 20 30
Kilometres

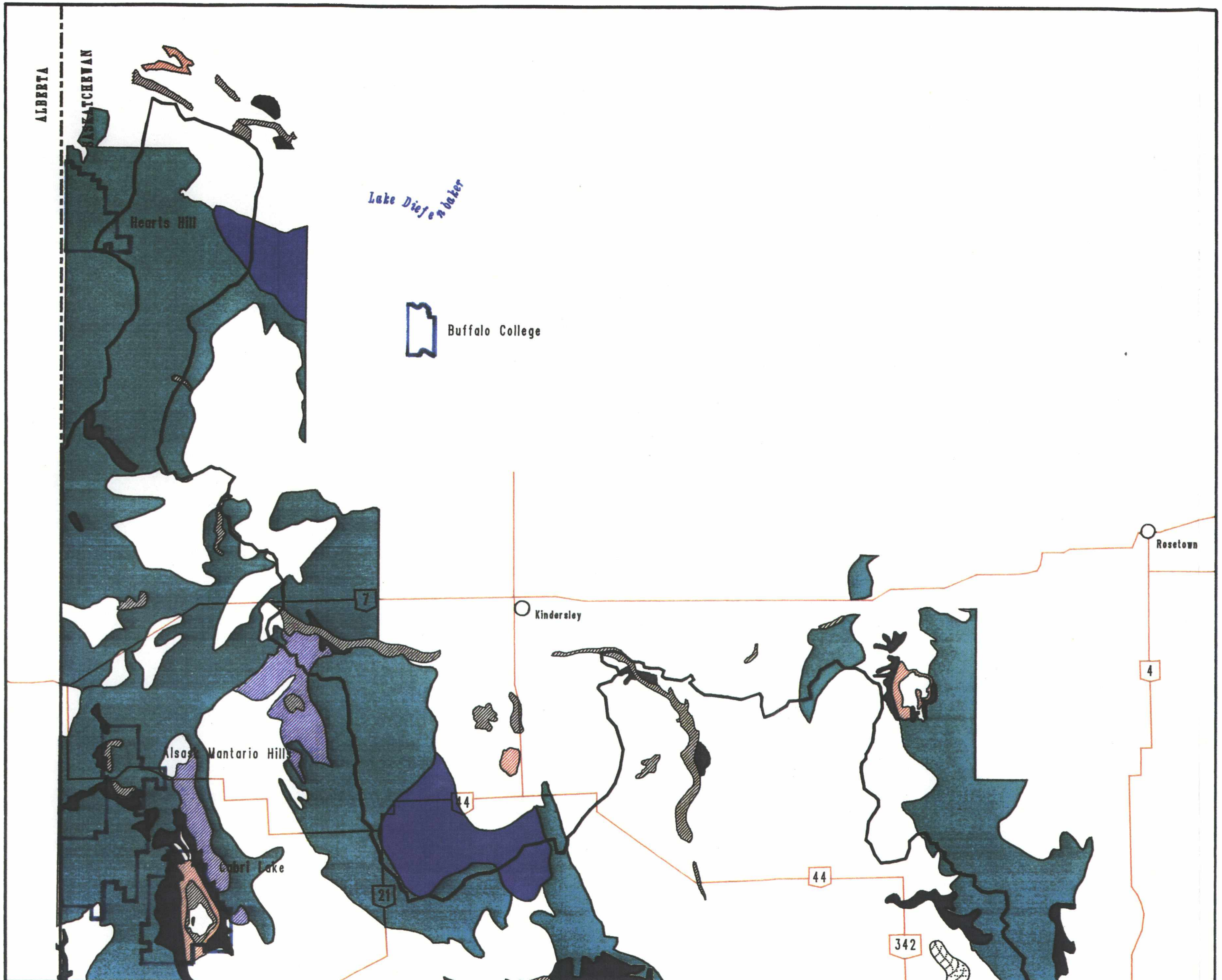


Regional Map Context

Produced August 1990

EMA

South Saskatchewan River Basin
Map 4 of 6



ENVIRONMENTALLY SENSITIVE AREAS

Sensitive Terrain

- High relief, undulating to rolling topography
- Meltwater channels-moderately dissected slopes
- Gully complex-highly dissected slopes and tributaries

Sensitive Parent Material

- Aeolian-non stabilized, wind borne deposits
- Alluvium-fine textured, river borne sediments

Sensitive Drainage Features

- Active flood-plains and tributaries
- Organic wetland complex
- Organic fenland

Sensitive Soils

- Predominantly saline soils
- Occasional saline soils
- Predominantly solonetzic (hardpan) soils
- Occasional solonetzic (hardpan) soils

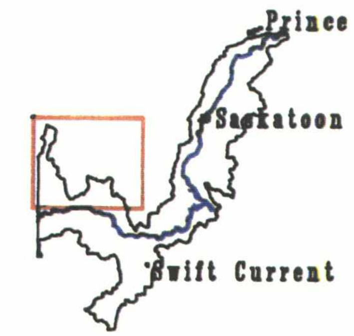
- IBP / Natural Areas
- South Saskatchewan River Basin boundary
- Divided highway
- Main highway

N

Scale = 1:500,000

4 0 10 20 30

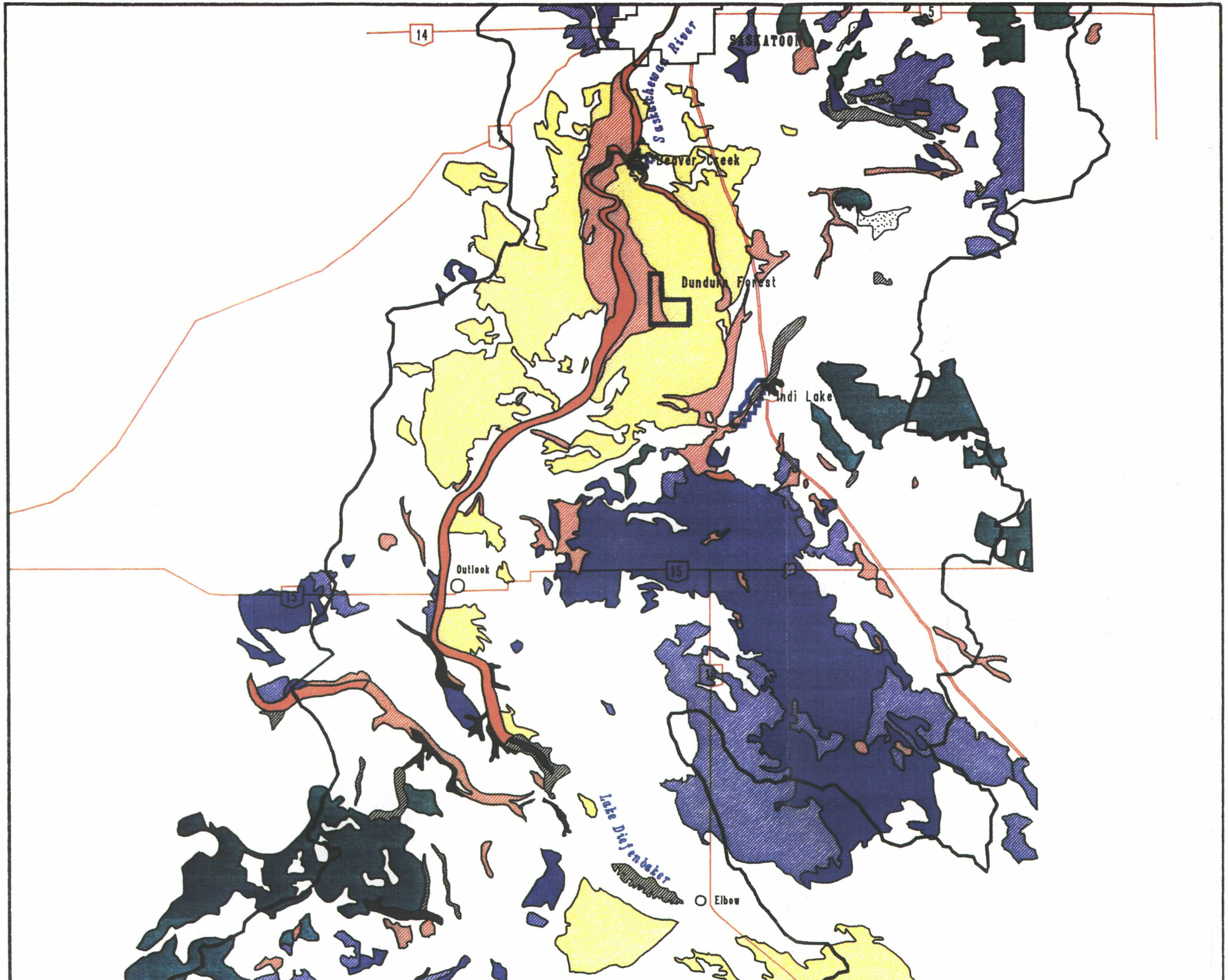
Kilometres



Regional Map Context

Produced August 1990

EMA



South Saskatchewan River Basin
Map 5 of 6

ENVIRONMENTALLY SENSITIVE AREAS

Sensitive Terrain

- High relief, undulating to rolling topography
- Meltwater channels-moderately dissected slopes
- Gully complex-highly dissected slopes and tributaries

Sensitive Parent Material

- Aeolian-non stabilized, wind borne deposits
- Alluvium-fine textured, river borne sediments

Sensitive Drainage Features

- Active flood-plains and tributaries
- Organic wetland complex
- Organic fenland

Sensitive Soils

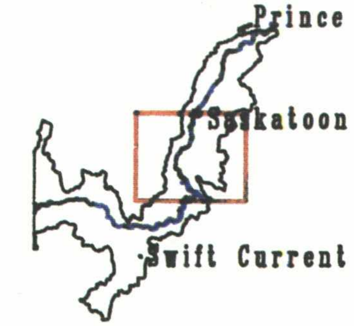
- Predominantly saline soils
- Occasional saline soils
- Predominantly solonetzic (hardpan) soils
- Occasional solonetzic (hardpan) soils

- IBP / Natural Areas
- South Saskatchewan River Basin boundary
- Divided highway
- Main highway

N

Scale = 1:500,000

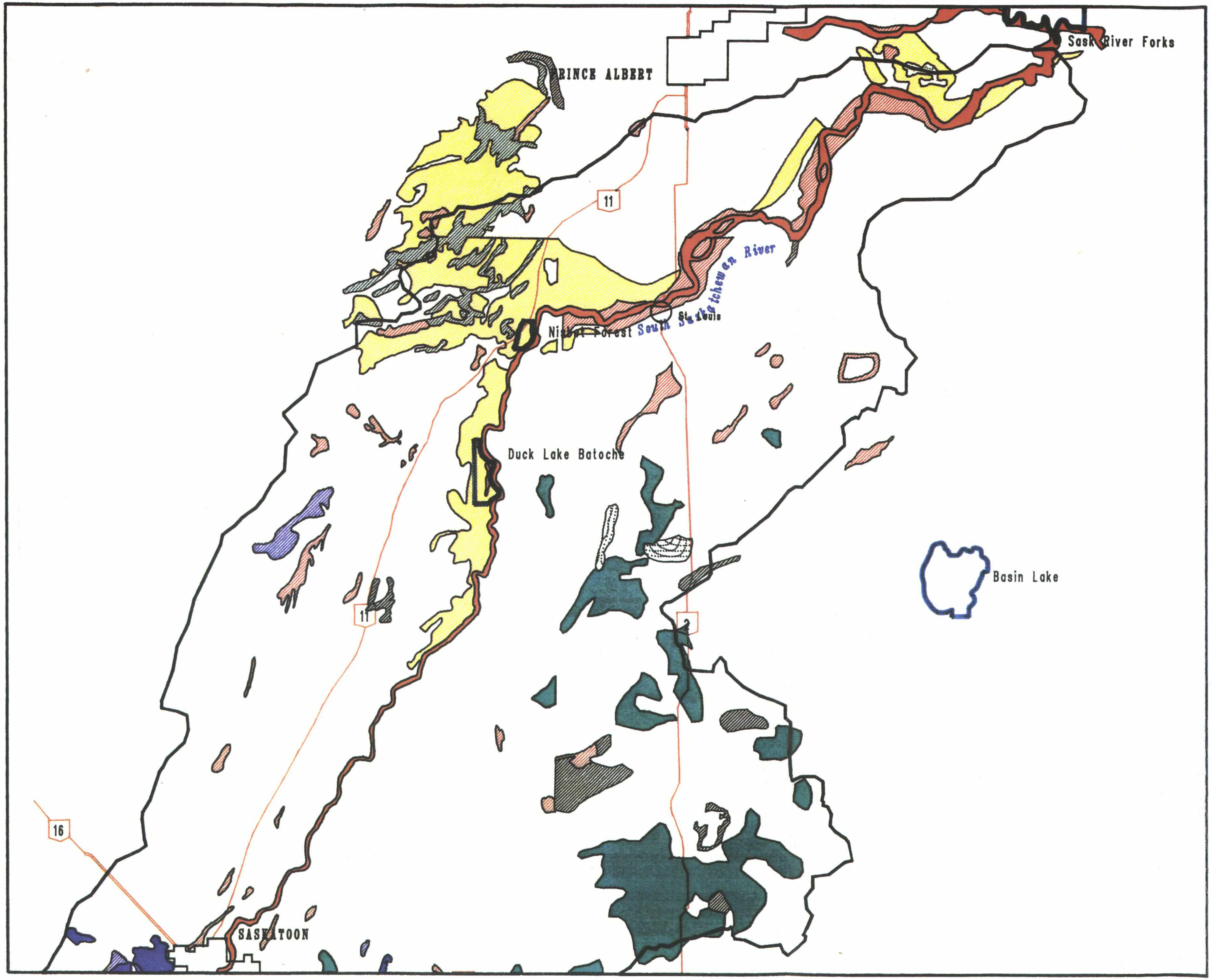
4 0 10 20 30
Kilometres



Regional Map Context

Produced August 1990

AEMA



South Saskatchewan River Basin
Map 6 of 6

ENVIRONMENTALLY SENSITIVE AREAS

Sensitive Terrain
- High relief, undulating to rolling topography
- Meltwater channels- moderately dissected slopes
- Gully complex- highly dissected slopes and tributaries

Sensitive Parent Material
- Aeolian- non stabilized, wind borne deposits
- Alluvium- fine textured, river borne sediments

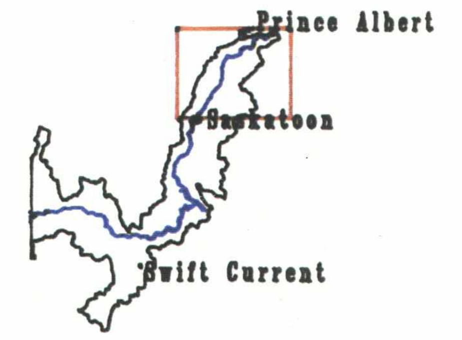
Sensitive Drainage Features
- Active flood-plains and tributaries
- Organic wetland complex
- Organic fenland

Sensitive Soils
- Predominantly saline soils
- Occasional saline soils
- Predominantly solonetzic (hardpan) soils
- Occasional solonetzic (hardpan) soils

- IBP / Natural Areas
- South Saskatchewan River Basin boundary
- Divided highway
- Main highway

Scale = 1:500,000

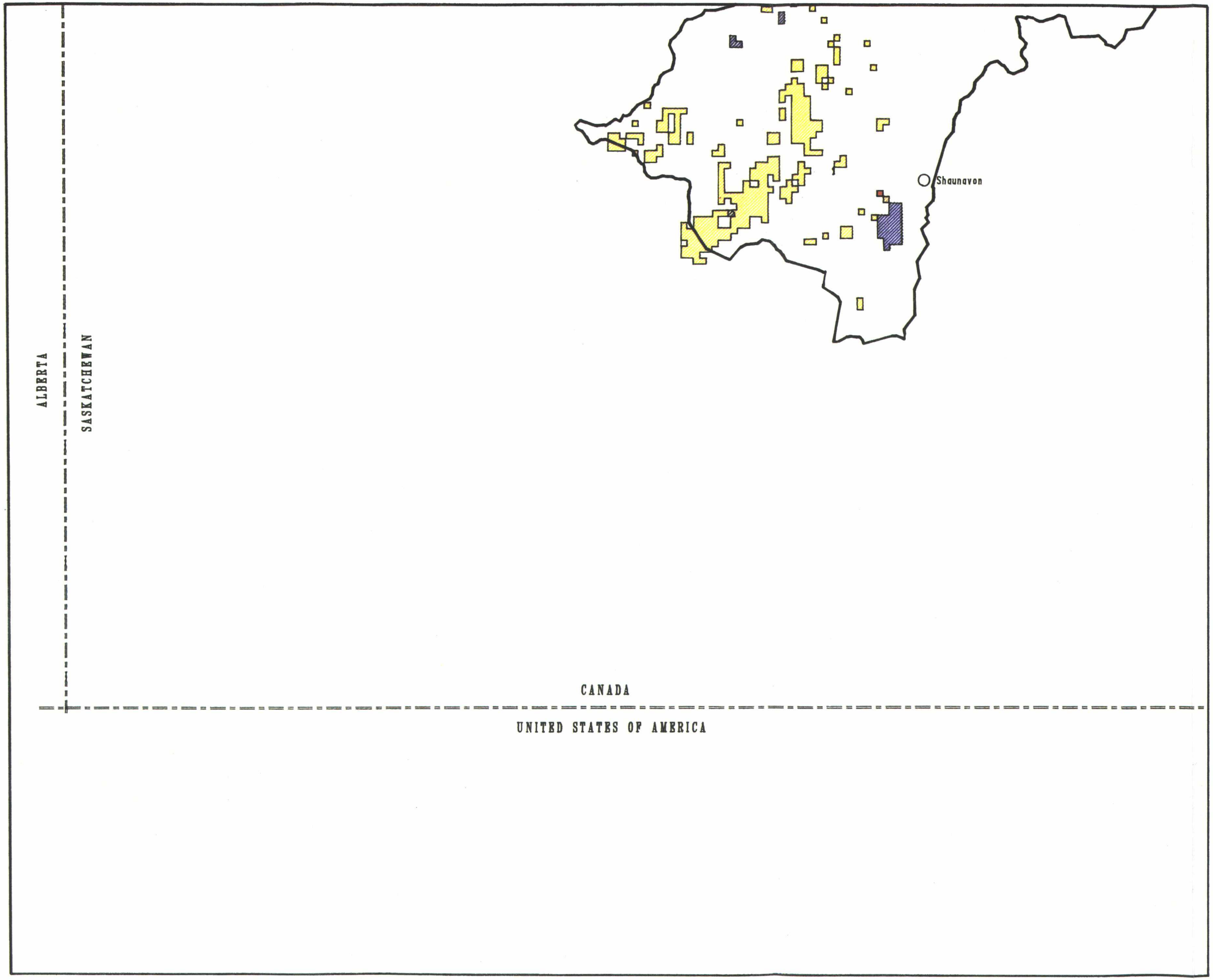
4 0 10 20 30
Kilometres



Regional Map Context

Produced August 1990

AEMA



South Saskatchewan River Basin Map 1 of 6

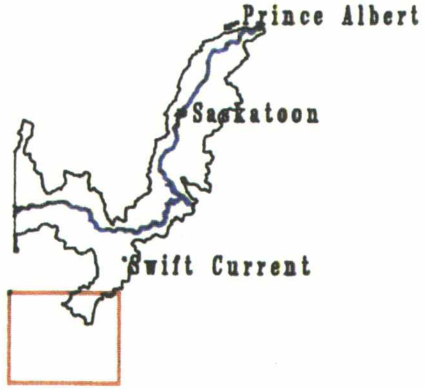
Land Tenure Legend

- Privately owned land
- Privately leased, provincial crown land
- Pasture (PFRA, Provincial Community and Co-op)
- Provincial Land Bank land
- Wildlife Development Fund land
- Vacant crown land
- Canadian Wildlife Service land
- DPRR land
- Other Government lands
- South Saskatchewan River Basin boundary
- Divided highway
- Main highway

Scale = 1:500,000

4 0 10 20 30

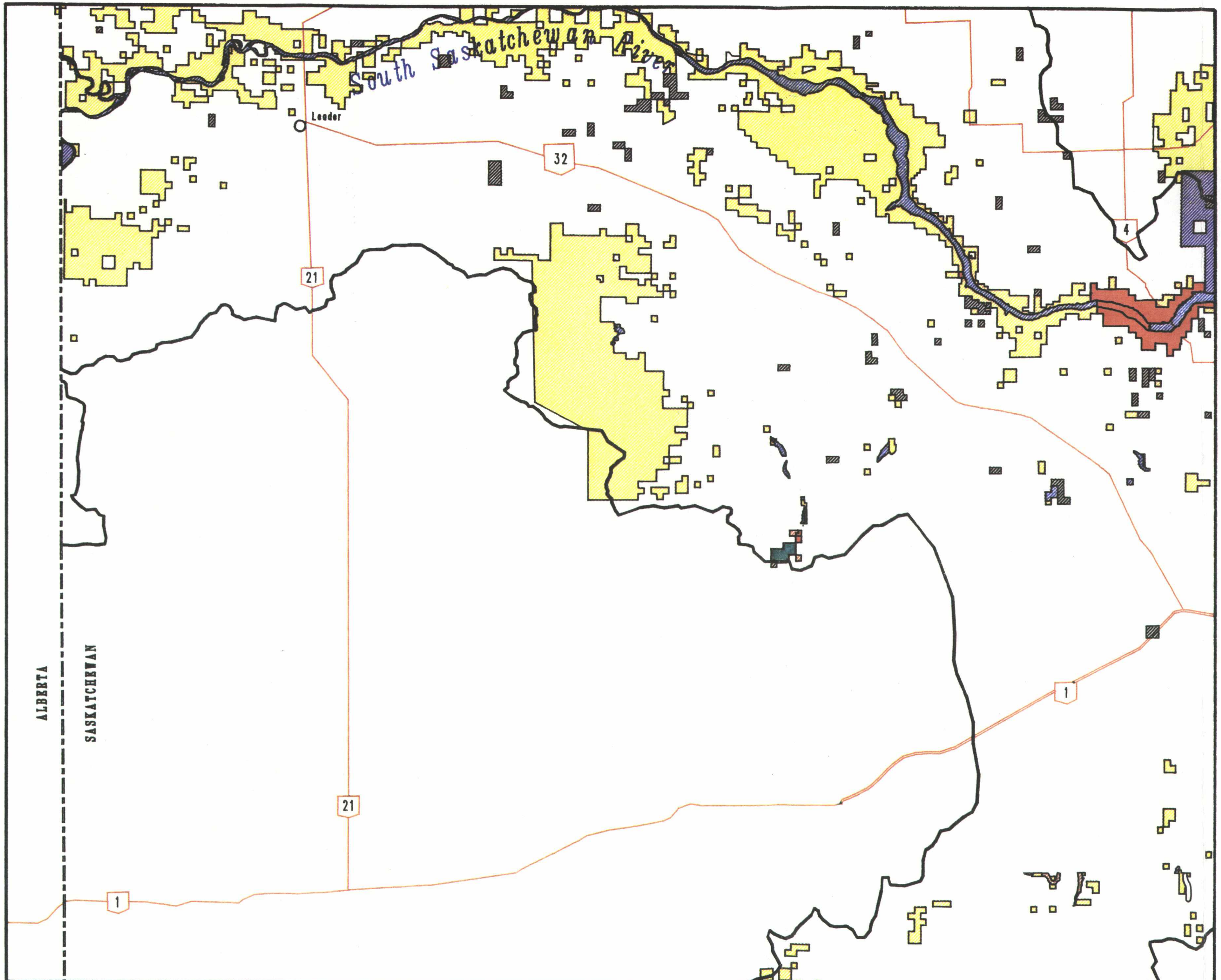
Kilometres



Regional Map Context

Produced August 1990

South Saskatchewan River Basin Map 2 of 6

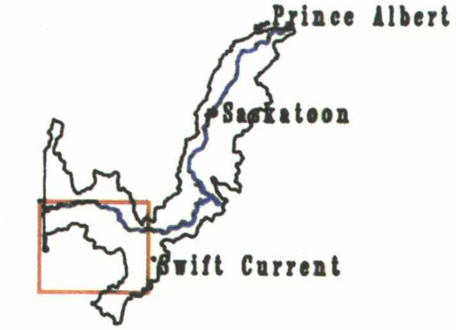


Land Tenure Legend

- Privately owned land
- Privately leased, provincial crown land
- Pasture (PRFA, Provincial Community and Co-op)
- Provincial Land Bank land
- Wildlife Development Fund land
- Vacant crown land
- Canadian Wildlife Service land
- DPRR land
- Other Government lands
- South Saskatchewan River Basin boundary
- Divided highway
- Main highway

Scale = 1:500,000

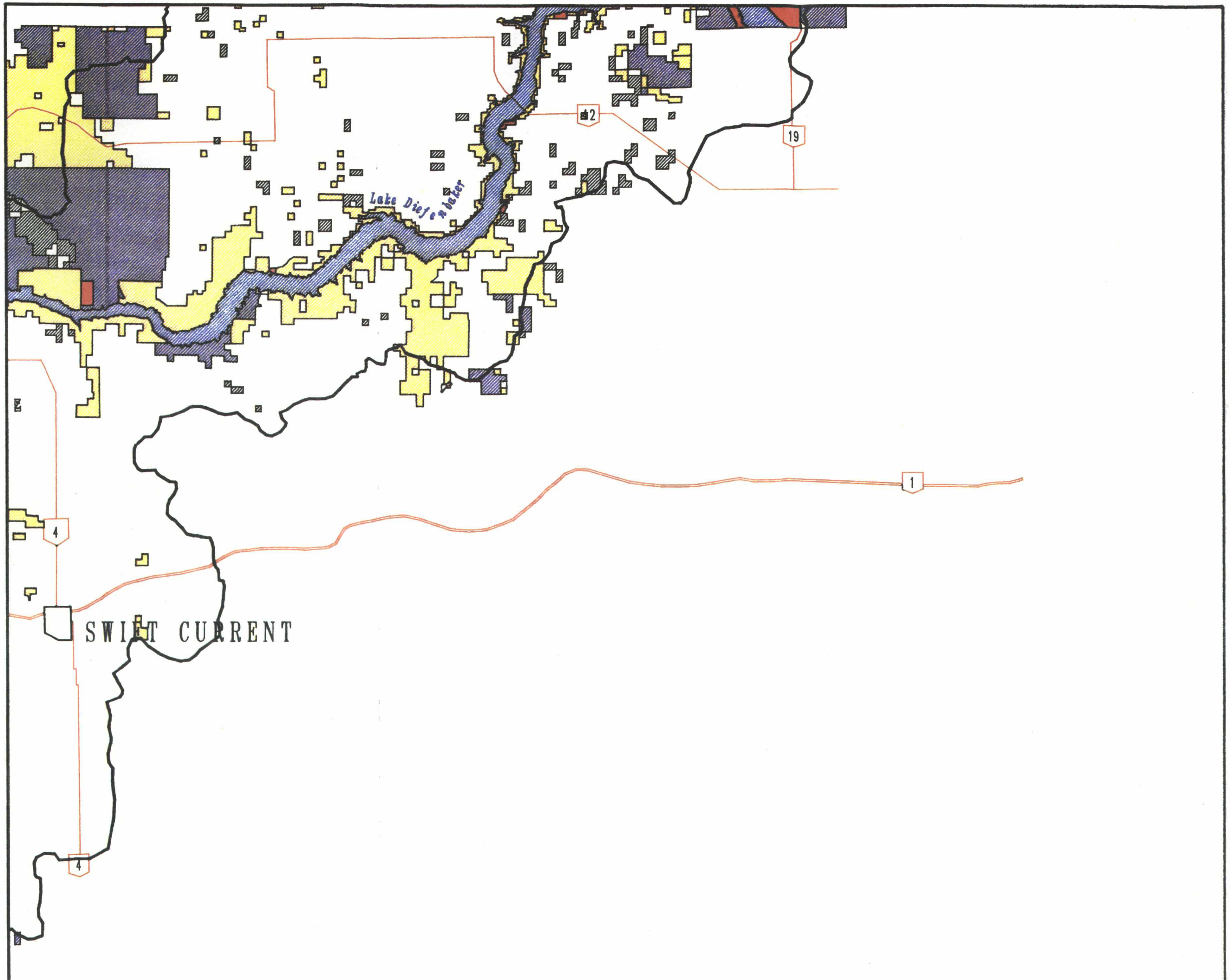
4 0 10 20 30
Kilometres



Regional Map Context

Produced August 1990

AEMA



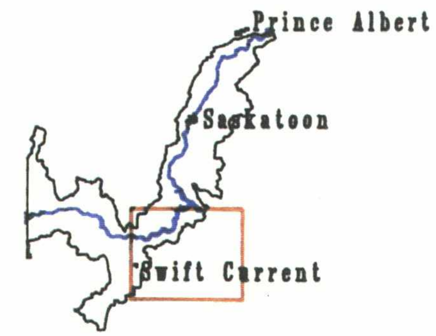
South Saskatchewan River Basin
Map 3 of 6

Land Tenure Legend

- Privately owned land
- Privately leased, provincial crown land
- Pasture (PRFA, Provincial Community and Co-op)
- Provincial Land Bank land
- Wildlife Development Fund land
- Vacant crown land
- Canadian Wildlife Service land
- DPRR land
- Other Government lands
- South Saskatchewan River Basin boundary
- Divided highway
- Main highway

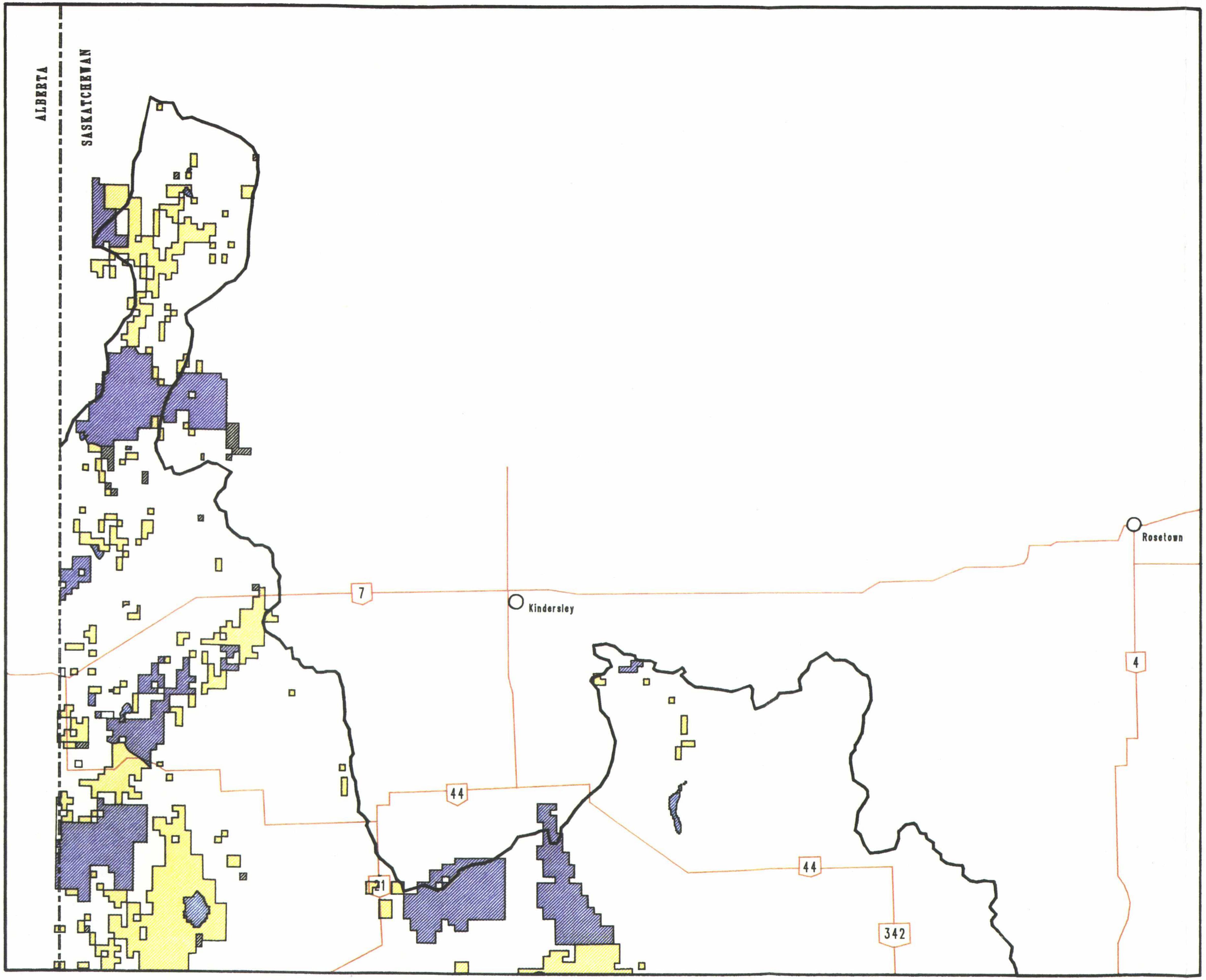
Scale = 1:500,000

4 0 10 20 30
Kilometres



Regional Map Context

Produced August 1990



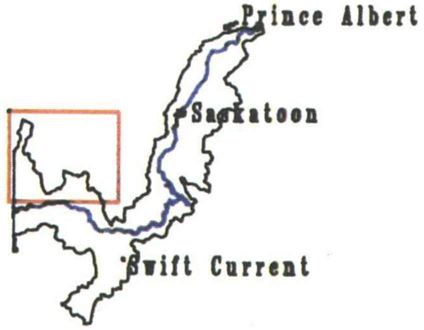
South Saskatchewan River Basin Map 4 of 6

Land Tenure Legend

- Privately owned land
- Privately leased, provincial crown land
- Pasture (PRFA, Provincial Community and Co-op)
- Provincial Land Bank land
- Wildlife Development Fund land
- Vacant crown land
- Canadian Wildlife Service land
- DPRR land
- Other Government lands
- South Saskatchewan River Basin boundary
- Divided highway
- Main highway

Scale = 1:500,000

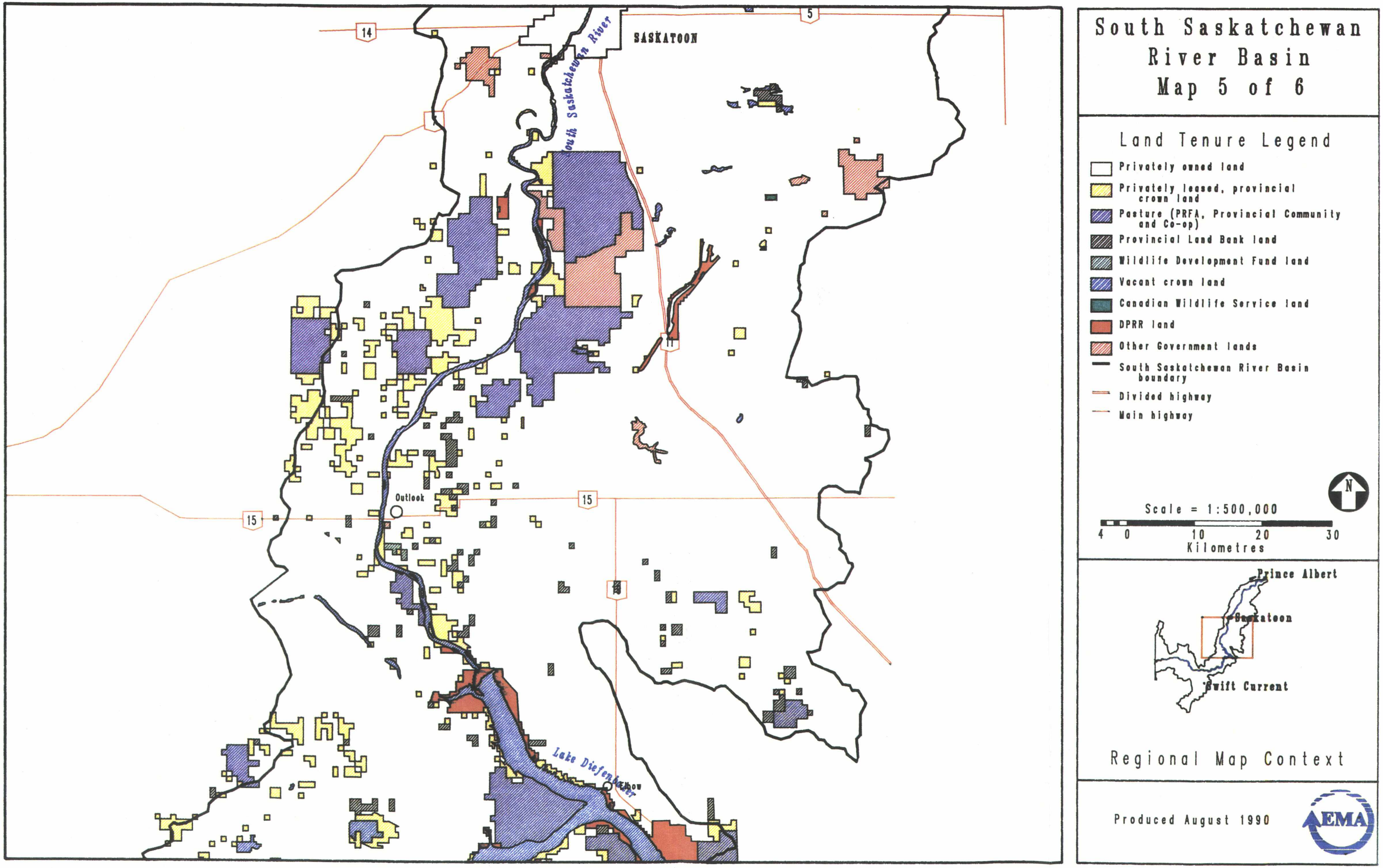
4 0 10 20 30
Kilometres

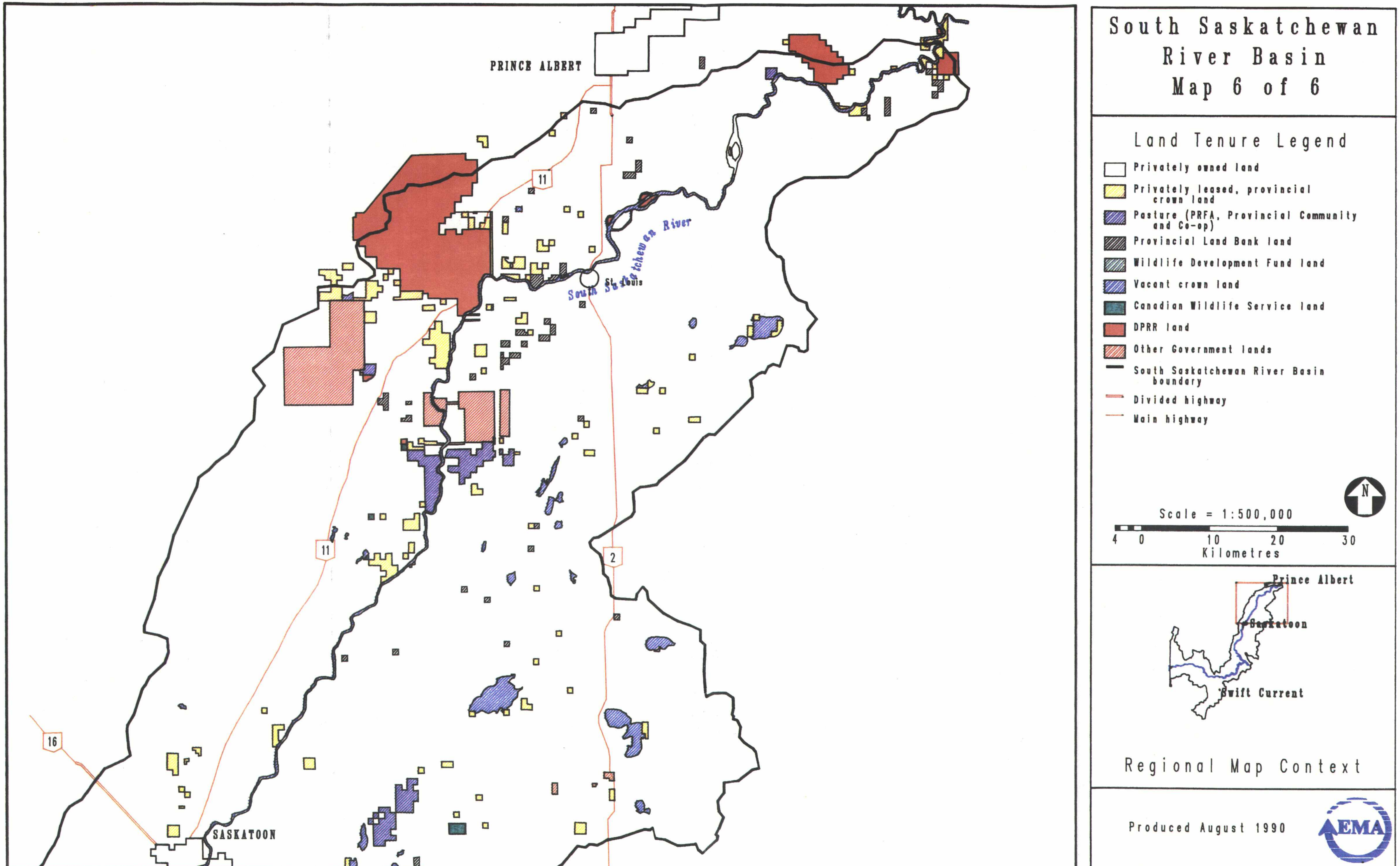


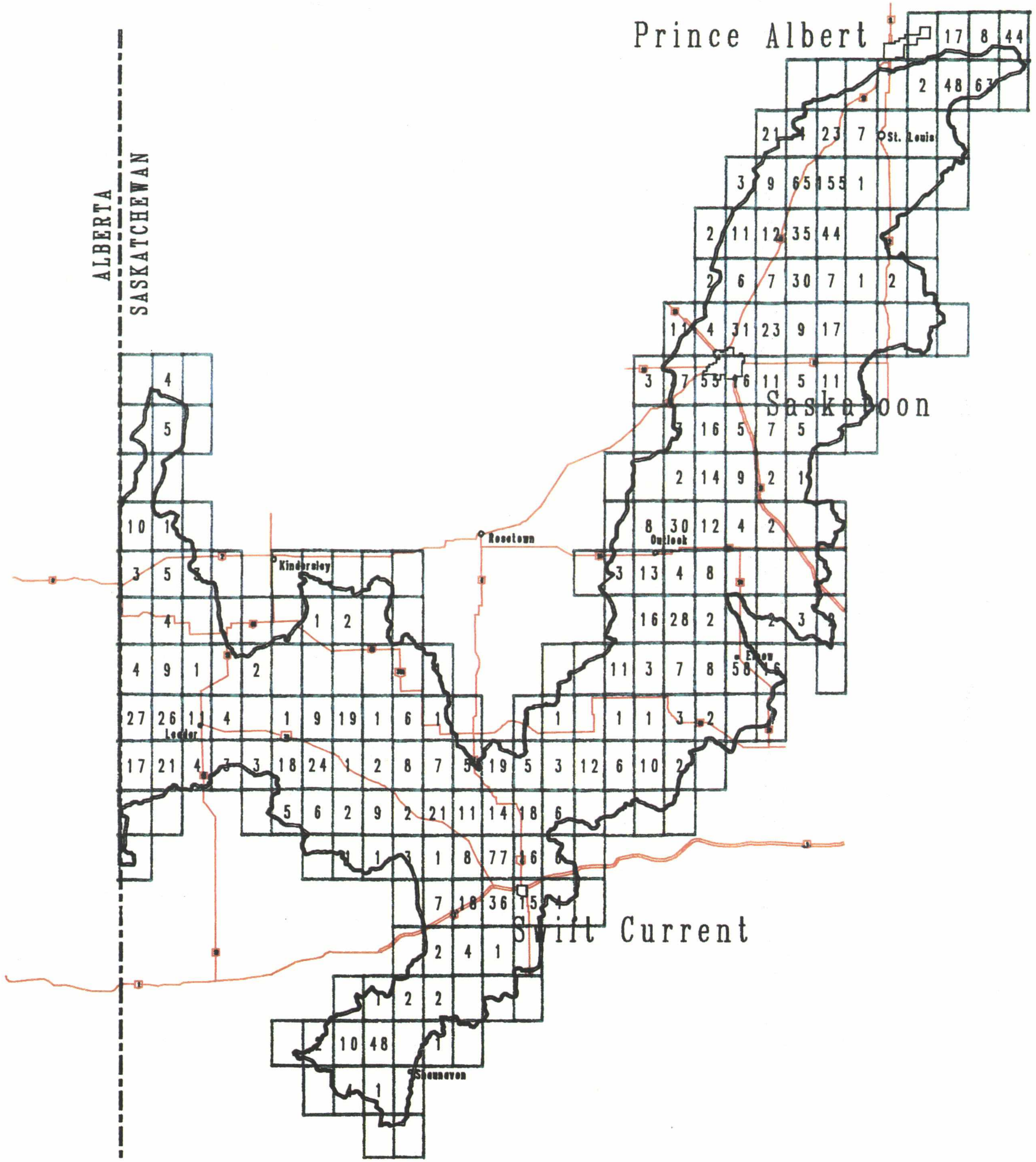
Regional Map Context

Produced August 1990

AEMA


South Saskatchewan River Basin Map 5 of 6
Land Tenure Legend
Privately owned land
Privately leased, provincial crown land
Pasture (PRFA, Provincial Community and Co-op)
Provincial Land Bank land
Wildlife Development Fund land
Vacant crown land
Canadian Wildlife Service land
DPRR land
Other Government lands
South Saskatchewan River Basin boundary
Divided highway
Main highway
Scale = 1:500,000
4 0 10 20 30
Kilometres
N
Prince Albert
Saskatoon
Swift Current
Regional Map Context
Produced August 1990
SASKATOON
South Saskatchewan River
Outlook
Lake Diefenbaker
Elbow
14
5
15
15
11


PRINCE ALBERT
SASKATOON
South Saskatchewan River
St. Louis
11
2
16
South Saskatchewan
River Basin
Map 6 of 6
Land Tenure Legend
Privately owned land
Privately leased, provincial crown land
Pasture (PFRA, Provincial Community and Co-op)
Provincial Land Bank land
Wildlife Development Fund land
Vacant crown land
Canadian Wildlife Service land
DPRR land
Other Government lands
South Saskatchewan River Basin boundary
Divided highway
Main highway
N
Scale = 1:500,000
4 0 10 20 30
Kilometres
Prince Albert
Saskatoon
Swift Current
Regional Map Context
Produced August 1990
AEMA



South Saskatchewan River Basin Known Heritage Sites

Legend

- Borden Block boundary
- South Saskatchewan River Basin boundary
- Divided highway
- Main highway

Note:

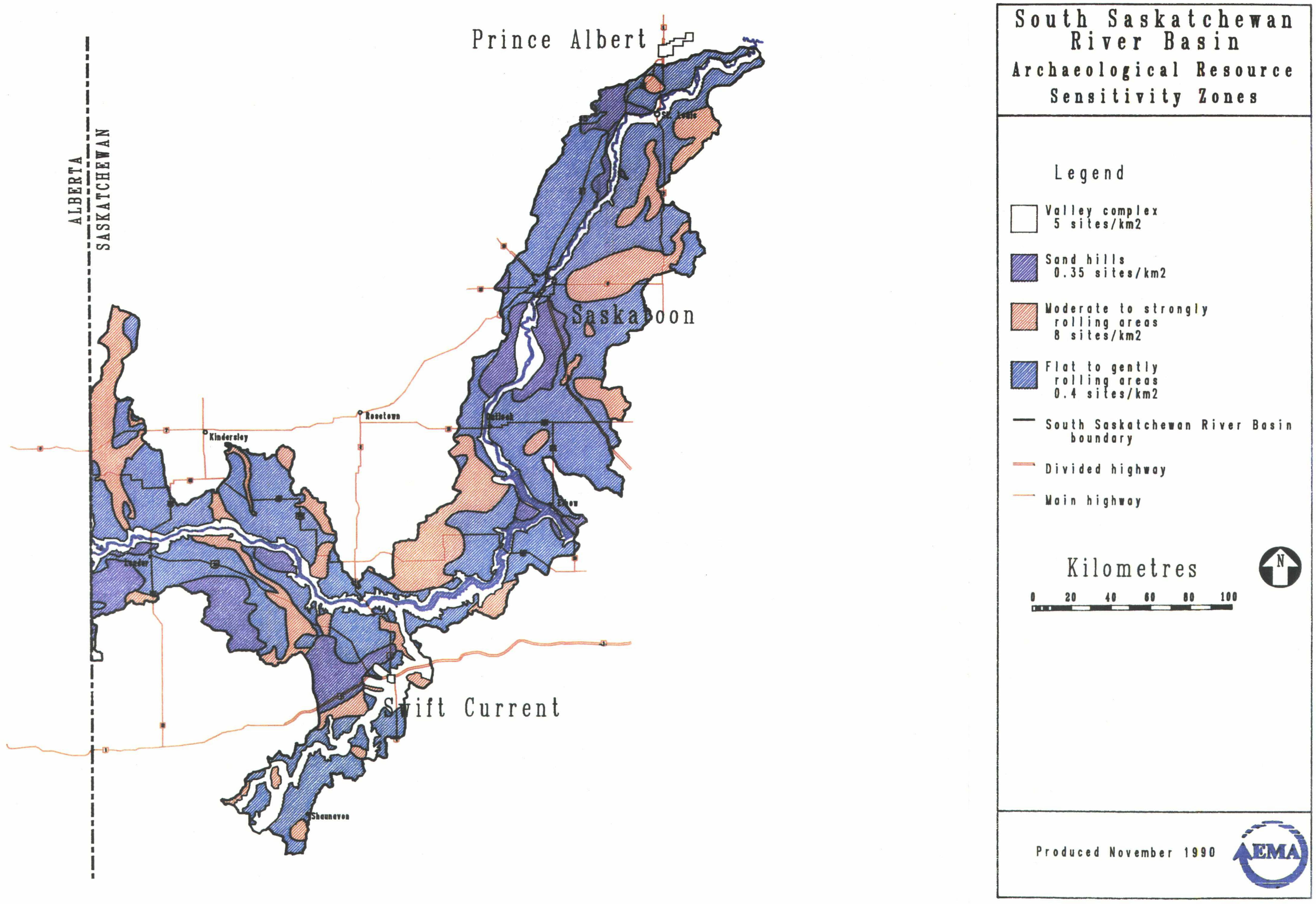
The number of Heritage Sites are listed for each Borden Block or portion of Borden Block in the South Saskatchewan River Basin.

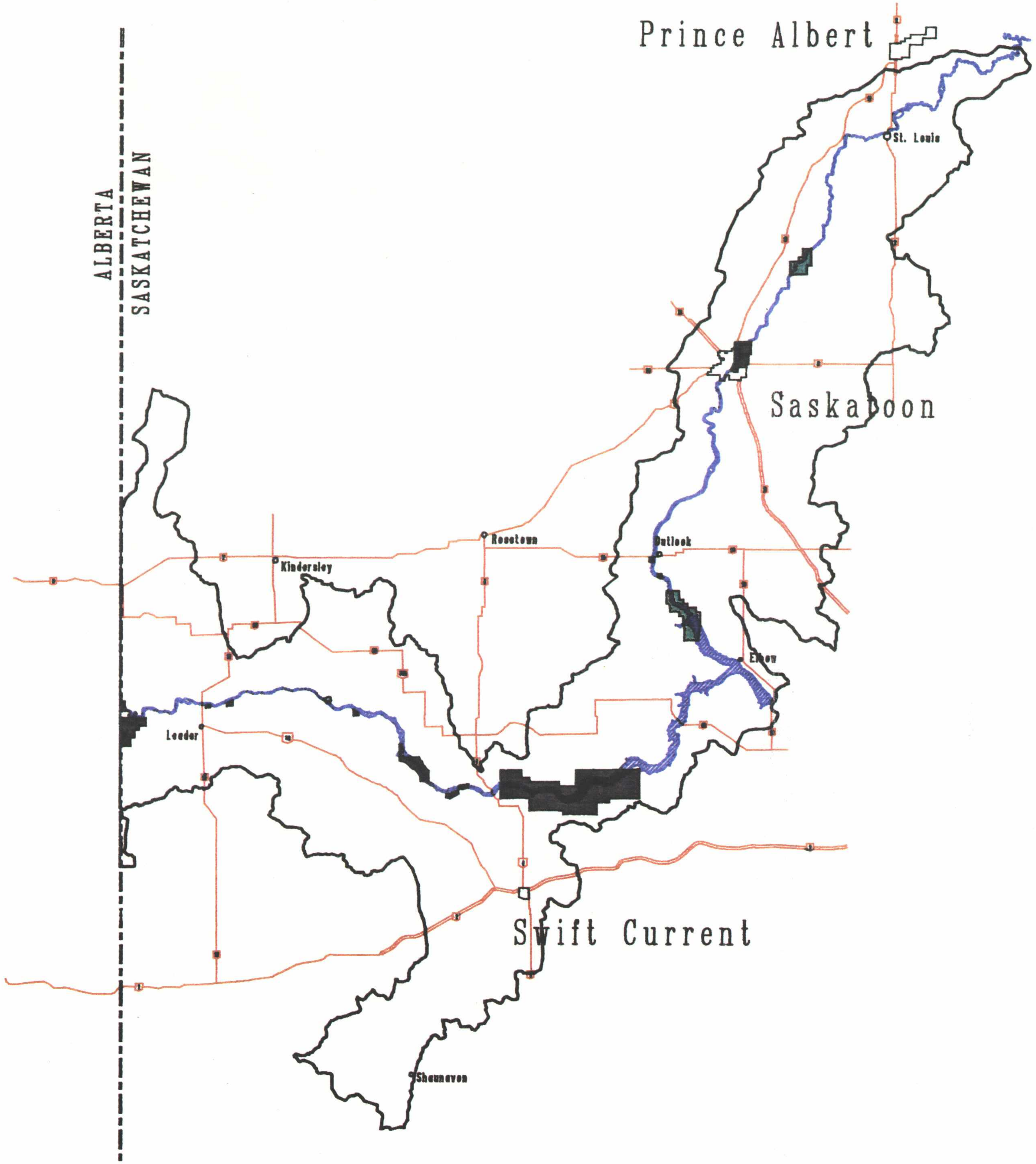
Kilometres

0 20 40 60 80 100

N

Produced November 1990


South Saskatchewan River Basin
Archaeological Resource Sensitivity Zones
Legend
Valley complex 5 sites/km2
Sand hills 0.35 sites/km2
Moderate to strongly rolling areas 8 sites/km2
Flat to gently rolling areas 0.4 sites/km2
South Saskatchewan River Basin boundary
Divided highway
Main highway
Kilometres
0 20 40 60 80 100
N
Produced November 1990
EMA
Prince Albert
Saskatoon
Swift Current
ALBERTA
SASKATCHEWAN
Rosetown
Kindersley



South Saskatchewan River Basin

Paleontogical Resource Sensitivity Zones

Legend

- High resource potential
- Medium resource potential
- South Saskatchewan River Basin boundary
- Divided highway
- Main highway

Kilometres

0 20 40 60 80 100

N

Produced November 1990