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PROPOSED WATER QUALITY OBJECTIVES FOR THE SOUTH SASKATCHEWAN RIVER BASIN

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Canada

PROPOSED WATER QUALITY OBJECTIVES FOR THE SOUTH SASKATCHEWAN RIVER BASIN

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South Saskatchewan River Basin Study

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I. INTRODUCTION

The South Saskatchewan River system is a high quality supply of water for diverse uses. It is possible, however, that the water resources of the system will not be able to sustain current and future use of the basin's supplies. Effective water quality management in the basin is essential in order to address the challenges of expanding and potentially conflicting water uses.

The South Saskatchewan River Basin Study is a major water planning study for that portion of the basin in Saskatchewan. The study, jointly undertaken by the Saskatchewan Water Corporation and Environment Canada, is intended to provide a framework plan to guide the short- and long-term management, conservation and development of the water and related resources of the basin. The Water Quality Technical Committee, with representatives from Environment Canada, Saskatchewan Environment and Public Safety, the City of Saskatoon, Saskatchewan Parks, Recreation and Culture, and National Hydrology Research Centre, is responsible for the development of basin-specific water quality objectives. The objectives will serve as a tool during the planning study for assessing the significance of water quality impacts of alternative water management and development strategies for the basin; and as a water management tool after the completion of the study.

This document presents the process the Committee followed in the development of water quality objectives, the principles underlying the objectives and the technical rationale culminating in the establishment of water quality objectives for the South Saskatchewan River Basin (SSRB).

II. THE DEVELOPMENT PROCESS

There are many stages involved in the development of water quality objectives. Some of the stages may occur at the same time, some are necessarily ordered and others feed back and may result in re-working of previously completed tasks. There is a high degree of interaction among all facets of the process. In the case of the SSRB Study, interaction took place not only between water quality initiatives but also between Water Quality Committee components and those more directly related to the Quantity, Use, Public Involvement and Management Strategies committees. The first stage was the identification of water quality issues. These were briefly discussed by the Water Quality Technical Committee (WQTC, Fall, 1986) and are summarized in Blachford and Goulden (in prep.). Primary issues are eutrophication, salinity and organic contaminants. Secondary issues relate to the quality of water delivered to the study area from Alberta and the quality and quantity which must be delivered to downstream reaches and to Manitoba. Other issues include interbasin transfers, point sources of pollutants and poor water quality in the Saskatoon Southeast Water Supply (SSEWS). The issues served as a focal point for the objectives development process.

Identification of water uses was the second stage. Water uses in the sub-regions of the basin were reviewed, under contract, for the Water Use Committee (Stanley Assoc. Eng. Ltd., 1987; Beak Assoc., 1987) and are summarized by Blachford and Goulden (in prep.). Objectives are developed for the most sensitive use, as if that use occurred at the site or region for which objectives are developed. The SSRB study office consulted with user groups to identify the public's concerns regarding water use. By incorporating public opinion, the values placed upon the resource and the effort expended to protect it form part of the objectives development process. Uses to be protected in each region of the basin are parameter-dependent.

Once the uses to be protected were identified, the water quality parameters and the sampling media relevant to the specific uses were selected. From this large list of relevant parameters, the most significant parameters which could act as indicators of whether or not a specific use might be in danger of being impaired were chosen. Activities at this point included an examination of the existing data base, including analyses of trends and seasonal patterns.

Most of the data base for the SSRB was reviewed at this stage. Trend analyses were conducted on appropriate parameters (Weagle, 1987). Metals and trace elements, suspended solids and physical parameters, bacteria and salts were evaluated in order to highlight problem reaches and/or levels of concern (Tones, 1988). Nutrient data were reviewed and summarized by reach (HydroQual and M.R.2 McDonald and Associates, 1988).

The data evaluation and analyses revealed some information gaps. A land use map for the basin (Saskmont, 1987), an investigation of phosphorus loading from non-point sources (Tones, 1987), a trophic state model for Lake Diefenbaker (SE & PS, 1988), an identification of organic contaminants present or possibly present in the basin (Saskmont, 1987) and a toxicity screening study (SRC, 1989) were undertaken as essential contributions to the water quality objectives development process. A fisheries and invertebrate fauna study of the mainstem and tributaries documented diversity and relative abundance (Miles and Sawchyn, 1988). A monitoring review (Weagle, in prep.) will aid in improving the effectiveness of future data collection.

Criteria and guideline information were compiled by Blachford and Goulden (in prep.). Criteria (scientific data which are evaluated to derive limits on parameter levels for water uses) and guidelines (concentrations derived from the criteria with the addition of a safety factor to support and maintain a water use) were evaluated by the Committee on an individual parameter basis to determine their relevance and applicability to the SSRB.

The selection of an appropriate water quality objectives development methodology depends upon all information collected up to this stage, i.e., issues, selected parameters, data review, criteria and guideline information. A review of various objectives development methodologies (Blachford, 1988) was made available to the Committee. Methodologies were selected for objectives development on a parameter-specific basis.

Aside from the actual formulation of the number or limiting statement that constitutes the water quality objective, other considerations must take place. Monitoring strategies must be evaluated and/or developed that will adequately service the objectives. A review process must be established in order that the objectives, once accepted, are continuously evaluated and upgraded when necessary. All decisions leading to the development of the specific objectives must be fully documented.

Ratification of the proposed objectives is the final stage prior to implementation. The Committee and independent advisors (as required) review all documented information and decisions. Ratification involves acceptance by senior levels of government. Implementation involves adequate surveillance monitoring by the responsible agencies and ongoing review to observe the effectiveness of the water quality objectives.

III. PRINCIPLES FOR THE DEVELOPMENT OF WATER QUALITY OBJECTIVES

Several principles (Thomson, 1987) were adopted by the Committee and used as guidelines during the development of objectives for the SSRB:

1. Objectives established cooperatively between jurisdictions for transboundary locations respect the sovereignty of each jurisdiction to manage the water resources within each portion of the basin as it sees fit.

   In the SSRB, the "sovereignty" of each reach or region of the basin was respected.

2. Objectives are established to protect the most sensitive agreed-upon designated downstream use.

   Uses in each region of the basin and uses downstream of the confluence of the South Saskatchewan River and the North Saskatchewan River were recognized.

3. Present and reasonably foreseeable water uses should be designated so that objectives will be consistent with the evolution of social and economic needs.

   Objectives support socially and economically sustainable water uses in the basin.

4. Objectives should be specific for each basin, river or river reach and

should be developed for interjurisdictional crossing points or basin management units.

> Objectives are considered separately for development in several water chemistry-distinct reaches of the SSRB.

5. Objectives should be developed for all parameters deemed to be significant by all parties.

> Consensus was reached on the parameters requiring water quality objectives.

6. Whenever possible, water quality objectives should endorse the ecosystem concept and consider the antagonistic, synergistic and additive effects of substances.

> Preliminary work towards identifying ecosystem health was undertaken.

7. Objectives should be subjected to ongoing review.

> Once accepted, the SSRB objectives will be assessed for effectiveness on a regular basis.

8. Water quality objectives are not legally binding numbers, but should be used to develop standards or effluent regulations by jurisdictions.

> The SSRB objectives will be used by the Study Board to evaluate water quality effects of future development alternatives and by local jurisdictions as goals of preferred water quality. They will be used after the study as a water quality management tool.

IV. TECHNICAL RATIONALE

The development of the proposed water quality objectives for the South Saskatchewan River Basin is presented for each of five parameter groups. For each group, the selection of parameters requiring water quality objectives, the water uses to be protected, the area of water quality objectives application and the proposed use-specific water quality objectives are documented. The parameter groups are: salinity, bacteria, nutrients, metals and organic contaminants.

Throughout the discussion, the following terms apply:

basin: refers to surface waters in the South Saskatchewan River Basin in Saskatchewan, including Swift Current Creek, Lake Diefenbaker and SSEWS.

guidelines: numerical concentration limit or narrative statement recommended to support and maintain a designated water use. Guidelines referred to in this document are the Canadian Water Quality Guidelines (CCREM, 1987).

objectives: numerical concentration or narrative statement which has been established to support and protect the designated uses of water at a specified site. "Proposed objectives" refer to those discussed for the basin; "Saskatchewan objectives" refer to the surface water quality objectives developed by Saskatchewan Department of Environment and Public Safety (1988).

sensitive use: the use of water (drinking, recreation, aquatic life, agriculture, industry) which is most acutely affected by the concentration of a water quality variable or group of variables.

non-degradation: the concept of not lowering the quality of water over time. This is compatible with a principle of the SSRB Study "The future development of the water resources in the basin should be consistent with the overall goal of sustainable economic development . . ."

Water quality objectives for drinking water are not proposed for the SSRB. Drinking water guidelines are available from Health and Welfare Canada (1987) and municipal drinking water objectives are available from Saskatchewan Environment and Public Safety (1980).

A. Salinity

The salinity, or total dissolved solids concentration, of water is of great importance in the SSRB due to the vast quantities of water used for irrigation purposes. An increase in salinity causes an increase in the osmotic pressure of the soil solution, resulting in a reduced availability of water for plant consumption.

The salinity of water is dependent upon the concentrations of sodium, calcium, potassium, magnesium, chloride, sulphate and carbonate/bicarbonate. The major source of these constituents is dissolution from parent soil and bedrock materials in the base flow of a waterway. Overland flow, anthropogenic sources and evaporative processes also influence the amount of dissolved substances.

Salinity may be expressed as total dissolved solids (TDS), as concentrations of each constituent or as specific conductance.

i) Selection of Parameters

All parameters listed in Table 1 are monitored in the SSRB. Agricultural guidelines exist for only a few of these parameters.

ii) Uses to be Protected

The agricultural use (irrigation) is the most sensitive to salinity. The use of secondary concern is livestock watering.

Aquatic life guidelines are not available. Cation ratios (sodium and potassium: calcium and magnesium) may influence algal distribution, but this would only occur at ratios much higher than those that currently exist in the SSRB. Therefore, aquatic life objectives are not developed for the SSRB.

iii) Area of Water Quality Objectives Application

The objectives apply everywhere in the basin where water is withdrawn for purposes of irrigation and livestock watering.

Table 1. Guidelines, Basin Values and Proposed SSRB Objectives for Agricultural Use Protection

Parameter	CCREM Guidelines (mg/L) Irrigation	CCREM Guidelines (mg/L) Livestock Watering	Saskatchewan Surface Water Quality Objectives (mg/L) Irrigation	Saskatchewan Surface Water Quality Objectives (mg/L) Livestock Watering	Basin Values (mg/L)	SSRB Proposed Objectives (mg/L) Irrigation	SSRB Proposed Objectives (mg/L) Livestock Watering
TDS	500 - 3500[1]	< 3000	700	< 1000	330-415 (Average)[3] 550 (Max)[3]	500	1000
Calcium		< 1000			191 (Max)[5] 128 (Max)[6]		
Magnesium					107 (Max)[5] 228 (Max)[6]		
Potassium					115 (Max)[5] 28 (Max)[6]		
Sodium			100		20.-21.4 (Average)[3] 24-143 (Med)[6] 30-108 (Med)[5]		
Chloride	100-700[1]		100		5.8-7.2 (Average)[4] 3.8-14 (Med)[5] 81-83 (Max)[6]		
Sulphate		< 1000		< 1000	64-72 (Average)[4] 85-325 (Med)[5] 1302 (Max)[6]		
SAR	2-10[1]		< 4.0-<12.0[2]		< 1[7] < 3 (Med)[8] < 3[5]	<3	

1 - Crop dependent
2 - Soil texture dependent
3 - Subbasins 1 - 5. Subbasin 6 (Swift Current Creek) values for TDS are 532-940 mg/L max. 1395
4 - Values from Leader, Outlook, Saskatoon and Birch Hills
5 - Values from Swift Current Creek Basin
6 - Values from SSEWS system
7 - Mainstem values, e.g., Leader - 0.65; Birch Hills - 0.66
8 - Median values from SSEWS - Max. values 3.16 and 3.55

iv) Proposed Use-Specific Water Quality Objectives

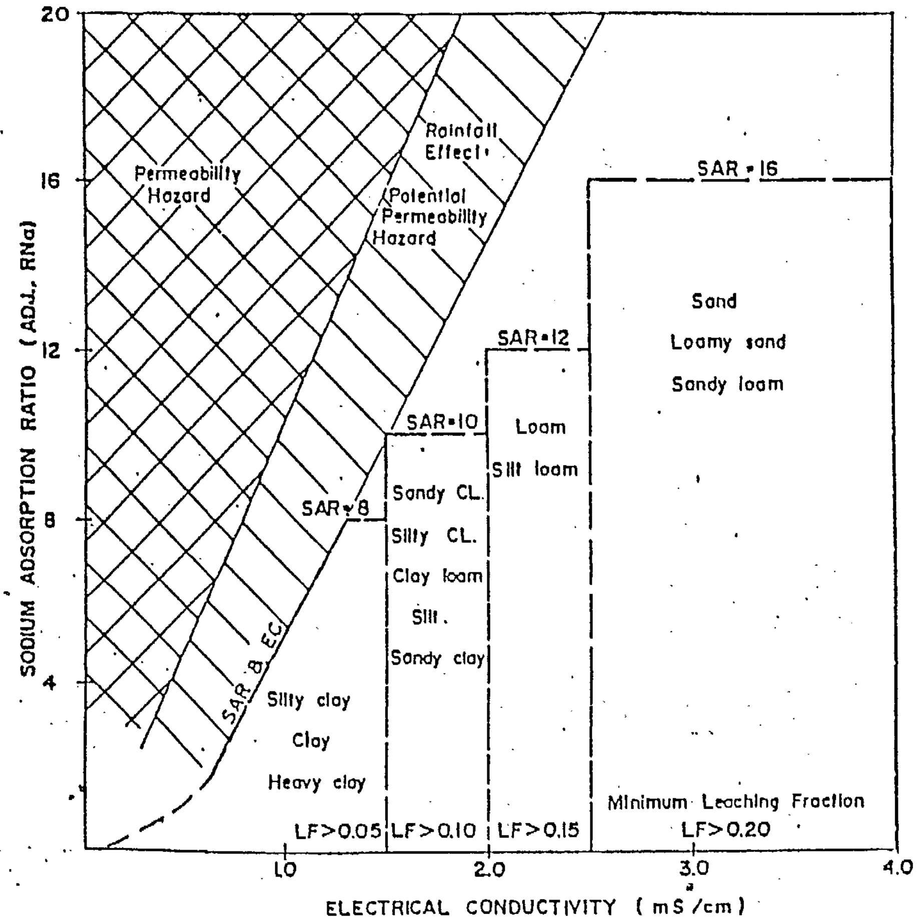
Objectives for Irrigation

It is recommended that water quality-soil compatibility guidelines, developed by Saskatchewan Agriculture (1986), based on the following philosophical framework, be adopted for the SSRB:

> "Saskatchewan soils are a valuable agricultural resource whose productivity can be enhanced by irrigation. While irrigation can provide the benefit of increased productivity, it can also damage the soil if the water quality is not compatible with the soil. The purpose of these guidelines is to maximize the benefits associated with irrigation with various water categories while minimizing any potential risks to soil degradation, crop quality and the environment. It is also the intent of these guidelines to ensure that agricultural lands benefit from irrigation and do not receive harmful quantities of undesirable elements".

These guidelines are based on a combination of salinity (as measured by electrical conductivity) and the adjusted sodium adsorption ratio (SAR), soil characteristics and leaching fractions to control the build-up of salts within a soil profile. The SAR evaluates the potential base exchange relationships in which the calcium and magnesium in a soil are replaced by the sodium present in the water. The adjusted SAR developed by Suarez (1981) takes into account the combination of salinity and SAR of the irrigation water and soil texture that will not result in a permeability problem (dispersion or clay swelling).

SALINITY AND ADJUSTED SAR GUIDELINES



To use the salinity and SAR guidelines, the following considerations should be taken into account:

- guidelines are only approximate and can be modified by management, climate and soil conditions.
- soils are well drained for each textural class.
- tolerant crops may be grown at higher ECs.
- ground water pollution can increase at higher ECs.
- site-specific soils and shallow hydrology investigations are recommended prior to intensive long term irrigation developments, particularly where the source water ECs exceed 1.4 mS/cm and SARs exceed 8.0.
- minimum required leaching fraction can be altered by irrigation management and utilized to re-evaluate maximum acceptable EC levels.
- texture of the least permeable soil horizon should be considered the "critical" texture for each category.
- responsible irrigation practices prevail.

It is recommended that, given the importance of irrigation in the basin, the SAR be maintained at < 3. SAR values of 3 - 9 in irrigation water create slight to moderate restrictions on use; values above 9 create severe restrictions. Mainstem SAR values in the SSRB are all < 1.

The TDS value of 500 mg/L is recommended as the objective. Average values in the basin are below this level. A salinity problem would not be expected if the TDS in irrigation water did not exceed 1000 mg/L, but sensitive crops would not be protected.

No objectives are proposed for parameters for which there are no guidelines and for which basin values are well below guideline levels.

Objectives for Livestock Watering

It is recommended that a TDS value of 1000 mg/L be accepted as the objective for the basin. Waters containing up to 3000 mg/L TDS are satisfactory for all classes of livestock and poultry, but some loss of productivity should be anticipated (CCREM, 1987). Mainstem values are considerably lower than the proposed 1000 mg/L objective.

No other objectives for livestock watering are recommended as existing guidelines (e.g., calcium, sulphate) are well above current basin values.

Should calcium and sulphate values increase, the situation should be re-evaluated.

B. Bacteria

Bacteriological contamination of water occurs from the discharge of inadequately treated wastewaters and from runoff from farm lands, feedlots and contaminated soils. Contamination of water primarily affects agricultural use, recreational use and drinking water.

The microbial content of water is measured indirectly by the use of indicator organisms. The indicators show the presence of fecal contamination, suggesting that pathogens may also be present. Coliforms and fecal streptococci are the most commonly used indicators. Coliforms are associated with the feces of warm-blooded animals and with soil. The use of fecal coliforms is more indicative of sanitary pollution than the use of total coliforms, because the fecal bacteria are restricted to the intestinal tract of warm-blooded animals. Fecal streptococci give a better estimate of the viral content of water than coliforms and may be the only indication of fecal pollution at points distant from the source.

i) Selection of Parameters

Total and fecal coliforms and fecal streptococci are measured at several sites in the basin. Total and fecal coliforms will be investigated for objectives development; fecal streptococci will not be considered at this time due to lack of guideline information.

Some agencies have recommended or are in the process of recommending the use of Pseudomonas aeruginosa as an indicator of health risk assessment at swimming beaches. Measurements of P. aeruginosa should be considered for the basin, and development of an objective, when the assessment as indicator is completed.

ii) Uses to be Protected

Bacterial contamination affects domestic, recreational, agricultural and some industrial uses of water. The most sensitive uses are irrigation and contact recreation.

iii) Area of Water Quality Objectives Application

The objectives are proposed specifically for the SSRB, taking into consideration local water quality conditions. As water is used throughout the basin for essentially all purposes, limits for protection of the most sensitive use apply basin-wide.

iv) Proposed Use-Specific Water Quality Objectives

Irrigation is the priority use in terms of quantity of water allocated to each use. It is recommended that the 100/100 ml guideline be adopted as the SSRB objective for fecal coliform for protection of the irrigation use (Table 2). This level is intended to protect consumers of vegetables irrigated with surface waters.

The geometric mean density of 200/100 ml should be adopted as the objective for contact recreation (CCREM, 1987; SE & PS, 1988). The values should be based on at least five samples obtained over a 30-day period. A fecal coliform density of more than 400/100 ml should be followed up immediately by repeat analysis. Contact recreation concerns those activities which involve direct contact between the human body and surface water for prolonged periods, or activities where inhalation/ingestion of surface water is likely to occur. Such activities include swimming, water skiing, bathing and wading.

Objectives for fecal streptococci are not proposed due to lack of guideline information. It is recommended, however, that fecal streptococci data be used to support water quality survey information and to assist in

Table 2. Guidelines, Basin Values and Proposed SSRB Objectives for Bacteria
I: Irrigation use; C: Contact use; NC: Non-contact use.

Parameter	CCREM Guidelines (per 100 ml)	Saskatchewan Surface Water Quality Objectives (per 100 ml)	Basin Values (per 100 ml) Max.	Geo. Mean	Proposed SSRB Objectives (per 100 ml)
Total Coliform	1000 I	1000 I 5000 NC	50-150000	4-4028	1000 I
Fecal Coliform	100 I 200 C	100 I 200 C 1000 NC	10-120000	1-1592	100 I 200 C
Fecal Streptococci			10-1380	2-846	

determining the nature and extent of pollution in surface waters (Health and Welfare Canada, 1983).

C. Nutrients

Nutrient quality is of concern due to the potential for growth of excessive or unwanted amounts of algae or aquatic weeds. The environmental impact of nutrients is manifested by a change in trophic status of a waterbody and subsequent impairment of desired water uses.

Eutrophication is not only a function of nutrient concentrations but also of other factors including water velocity (impacts upon the habitat of a nutrient supply to plants), sediment types (determine relative presence of macrophytes and periphyton), light availability, water temperature (affects growth rate), and grazing (invertebrate grazing impacts upon biomass production). These factors must be considered during the development of nutrient water quality objectives.

Because of the indirect effect of nutrient levels on water uses, biomass levels which impair water use are determined first, then nutrient levels which create growth of those biomass levels are identified. Biomass/use observations have been made by Hamilton (1983) for the Alberta side of the South Saskatchewan River Basin. Similar observations exist for downstream of Saskatoon (Hamilton and Griffiths, 1985) and in general (Tones, 1987).

Development of nutrient objectives that minimize unwanted growth of aquatic plants requires consideration of factors including amount (and type) of productivity tolerated, determination that nutrients are limiting to growth, determination of the limiting nutrient, and the critical nutrient concentration for the water body's characteristics and plant life. The critical nutrient level is considered the concentration above which the rate of plant growth is independent of the nutrient concentration. Below the critical level, the growth rate is directly related to the concentration of the nutrient in shortest supply. Limiting nutrients can be ascertained from nitrogen to phosphorus (N:P) ratios. Tones (1987) and Hamilton (1985) propose N:P which are nutrient limiting.

i) Selection of Parameters

Objectives are developed for soluble reactive phosphorus (rivers only), total phosphorus (lake and reservoirs only), and total ammonia.

Soluble reactive phosphorus (SRP) is considered the readily bioavailable form of phosphorus. Algae and macrophytes respond to nutrients available in the water column, thus SRP is the phosphorus species of most importance in a flowing system. The longer residence time in lakes and reservoirs permits time for non-available forms to be biologically and chemically converted; therefore, a total phosphorus objective for lakes and reservoirs is developed.

An objective is proposed for total ammonia to protect against ammonia toxicity to aquatic organisms. Excessive nitrate and nitrite concentrations may cause methemoglobinemia; this is a human health concern and is not dealt with in this document.

ii) Uses to be Protected

Nutrient concentrations (except for ammonia) do not have a direct effect on any water use. Their impact is realized indirectly through biological enrichment of the system, including growth of macrophytes and algae attached to the substrate in rivers and growth of planktonic algae in reservoirs.

Enrichment may impair water for various uses. Domestic and municipal supplies are affected by taste and odour causing organisms, an increased need for clarification and generation of process-related substances (e.g., chloro-organics). Recreation is adversely affected by a reduction in clarity, offensive aesthetics and undesirable weed growth. Agricultural uses are affected by impairment of livestock watering supplies (e.g., toxic cyanophytes) and by disruptions to irrigation supply and distribution. Fisheries and other aquatic life are adversely affected by low oxygen concentrations caused by excessive diurnal respiration and decomposition, and by physical habitat impairment.

In developing the objectives, the lowest value was selected based upon the most stringent water use to be protected in each basin area.

iii) Area of Water Quality Objectives Application

Objectives are developed independently for Lake Diefenbaker, the mainstem, and for Swift Current Creek and the SSEWS reservoirs.

iv) Proposed Water Quality Objectives

Nutrient objectives for the basin are in Table 3.

Lake Diefenbaker

The trophic status of Lake Diefenbaker ranges from mesotrophic in the upper reaches to oligotrophic in the lower reaches (SE & PS & IWD, 1988), based on in-lake measurements of total phosphorus, chlorophyll a and phytoplankton. Maintenance of at least mesotrophic or better conditions in all areas of the lake would ensure avoidance of problems such as algal blooms, deoxygenation and unpleasant taste and odour. Considerable effort has been spent on deriving phosphorus objectives for Lake Diefenbaker to maintain the mesotrophic status and for the South Saskatchewan River to control inputs to the lake. A trophic state model for Lake Diefenbaker was developed (SE & PS, 1988) to examine the response of the lake to various nutrient inputs, thereby contributing to the development of water quality objectives.

The trophic model is based upon the concepts in OECD (1982): when the productivity of a water body is controlled by a limited supply of a single nutrient, it is directly related to the addition of that nutrient. Given that the limiting nutrient is phosphorus (SE & PS & IWD, 1988), a model was developed that related phosphorus supply to the concentration of chlorophyll a in the photic zone. Modifications to the OECD model were made so that the model was specific to Lake Diefenbaker. Relationships between variables (e.g., chlorophyll a, phosphorus, secchi depth, non-filterable residue) in each lake area were determined and incorporated in the model, based upon a two year data base. Chlorophyll a was found to be the most accurate for prediction of phosphorus levels (i.e., high chlorophyll a-phosphorus correlation coefficient), and was, therefore,

Table 3. Proposed SSRB Objectives for Nutrients

	Soluble Reactive Phosphorus	Total Phosphorus	Total Ammonia
Lake Diefenbaker			
at Saskatchewan Landing		0.061 mg/L	
at Herbert		0.059 mg/L	
at Riverhurst		0.058 mg/L	
at Douglas		0.058 mg/L	
at Danielson		0.058 mg/L	
Mainstem South Saskatchewan River			
upstream of Lake Diefenbaker		[1]	CCREM[2]
downstream of Lake Diefenbaker	<0.005 mg/L		CCREM
Swift Current Creek	<0.005 mg/L		
SSEWS Reservoirs			
Broderick		<0.03 mg/L	CCREM
Brightwater		<0.03 mg/L	CCREM
Blackstrap		<0.03 mg/L	CCREM
Bradwell		<0.05 mg/L	CCREM
Zelma		<0.03 mg/L	CCREM
Dellwood		<0.03 mg/L	CCREM
Little Manitou		<0.05 mg/L	CCREM

1 Maintain oxygenated conditions at sediment-water interface.
2 CCREM, 1987. Chapter 3-19. Maintain total ammonia at guideline levels.

chosen as trophic indicator for the lake. The following boundary levels (Vollenweider, 1976) were selected:

Eutrophic	chlorophyll a > 0.008 mg/L
Mesotrophic	0.003 mg/L > chlorophyll a < 0.008 mg/L
Oligotrophic	chlorophyll a < 0.003 mg/L

Maintenance of mesotrophic or less productive conditions in all lake areas requires that the chlorophyll a concentrations be less than 0.008 mg/L. A relationship was developed to achieve these conditions based upon phosphorus, nonfilterable residue (because of the effect of light availability on productivity), and chlorophyll a levels. The relationship was used to calculate the following water quality objectives for the five lake areas for total phosphorus:

0.061 mg/L at Saskatchewan Landing
0.059 mg/L at Herbert
0.058 mg/L at Riverhurst
0.058 mg/L at Douglas
0.058 mg/L at Danielson (SE & PS, 1988).

It is recommended that the above values be the phosphorus objectives for Lake Diefenbaker.

Mainstem South Saskatchewan River

The challenge in developing water quality objectives for nutrients in the mainstem upstream of Lake Diefenbaker is in determining what inflowing nutrient concentrations would limit or maintain the proposed Lake Diefenbaker nutrient objectives.

Total phosphorus in the lake originates from atmospheric, land, riverine and internal sources. Aquatic loadings dominate in all lake areas except Douglas, contributing from 73-94% of the total phosphorus loading (SE & PS, 1988). Land loadings varied from 6-27% (except for Douglas) and atmospheric loadings from 0-6% of the total phosphorus loading. The Douglas area differs from the other lake areas, having a much greater contribution of land loadings, due to its unique morphology and hydrology. It was concluded that aquatic loadings were the only external phosphorus source that could cause changes in the trophic state of the lake.

Internal phosphorus loadings could result from regeneration of phosphorus from the sediments. Mass loading studies to Lake Diefenbaker show that the lake is a sink for phosphorus, with annual loads entering the lake exceeding those leaving the lake by a factor of 26:1 (Crosley and Weagle, 1989). It is expected that dissolved phosphorus is rapidly assimilated by plant communities and is recycled within the community as the water moves downstream in the lake. A portion of the dissolved fraction is deposited as organic phosphorus associated with algae. The particulate portion of the phosphorus load is rapidly deposited, particularly in the upper reaches of the lake. The sediments are approximately 45% apatite phosphorus, 45% non-apatite inorganic phosphorus and 11% organic phosphorus (Crosley and Weagle, 1989). Non-apatite inorganic phosphorus and organic phosphorus are potentially available for biological assimilation, thus about 55% of all sediment-phosphorus could be made available if phosphorus were released due to oxygen depletion at the sediment water interface. An extended period of oxygen depletion could result in sufficient phosphorus being released so that the lake would become eutrophic.

Oxygen concentrations in Lake Diefenbaker are generally high and uniform with depth, and hypolimnetic oxygen depletion is rare (SE & PS et al., 1988). Under these conditions, phosphorus release from the sediments would be minimal. Phosphorus release could conceivably occur, if, for example, stratification were to develop during an extended period of low or no wind and the bottom waters were to become anoxic, or if the oxygen regime of the lake were to change significantly.

Should an objective for phosphorus upstream of Lake Diefenbaker be developed? Most of the phosphorus going into the lake is sediment-phosphorus from natural sources (erosion products) and is not bioavailable under prevailing conditions. Dissolved phosphorus, which is available, enters the lake in relatively minor quantities. The concern centres upon maintaining Lake Diefenbaker in a mesotrophic state, which requires prevention of phosphorus release from the sediments. Therefore, in place of an objective for total phosphorus for the mainstem upstream of Lake Diefenbaker, it is recommended that every effort be made to limit developments upstream of the lake and on the lake which may adversely affect the oxygen regime of Lake Diefenbaker. This would be a more effective management strategy than the development and implementation of a water quality objective.

It is recommended that the concentration of total ammonia not exceed those presented by CCREM (1987). Historic records for the tributaries (South Saskatchewan River at Highway #41, Red Deer River at Bindloss) show that to date toxic levels have been rare.

Downstream of Lake Diefenbaker, the major water use is public water supply. It is recommended that <0.005 mg/L soluble reactive phosphorus be adopted as the objective, from Gardiner Dam to the confluence with the North Saskatchewan River to protect this use. Compliance with the objective would limit plant and algal densities thus minimizing taste and odour problems.

The reach downstream of Saskatoon experiences extensive aquatic plant growth. The plants could potentially interfere with recreational use of the river. Whether or not the plants impair a water use, whether minimizing nutrient levels would inhibit growth, and what level would result in a growth reduction are undecided. It is recommended, therefore, that development of a phosphorus objective for the reach downstream of Saskatoon be considered following conclusion of current plant-nutrient relationship research being conducted at the National Hydrology Research Institute.

It is recommended that the concentration of total ammonia not exceed those presented by CCREM (1987) for protection of aquatic life. The levels of total ammonia are based upon the variation of the toxic (unionized) component with pH and temperature. Historical records downstream of Saskatoon (at Clarkboro Ferry) indicate a moderate level of concern for toxic levels.

Swift Current Creek and the SSEWS Reservoirs

Nutrient objectives for Swift Current Creek and the Saskatoon Southeast Water Supply System (SSEWS) reservoirs are based upon protection of the public water supply, and protection of recreation and aquatic life in Bradwell and Little Manitou.

It is recommended that the objective < 0.005 mg/L soluble reactive phosphorus be adopted for Swift Current Creek (HydroQual and M.R.2 McDonald, 1988). Concentrations in the creek below this value will limit plant and algal densities thus minimizing taste and odour problems.

A total phosphorus objective of < 0.05 mg/L for Bradwell and Little Manitou would limit biological growth such that recreation and aquatic life would be protected. Concentrations below this level limit biomass densities such that boat passage and clogging of propellers are not impaired, and physical habitat impairment and diurnal oxygen fluxes are not critical. A more stringent objective of < 0.03 mg/L total phosphorus would be required for the remaining reservoirs to protect the public water supply (HydroQual and M.R.2 McDonald, 1988).

The objectives are intended for the open water season, when plant growth most impairs water uses, and should be applied as average seasonal concentrations as the plant community responds to prevailing conditions over the growth period.

It is recommended that the concentration of total ammonia not exceed those presented by CCREM (1987) for the creek and all reservoirs. The levels of total ammonia are based upon the variation of the toxic (unionized) component with pH and temperature.

D. Metals

Metals are known to exist in the surface waters of the South Saskatchewan River Basin. They originate from natural (soil and wind erosion) as well as anthropogenic (municipal and industrial effluents, urban runoff, agricultural inputs) sources. The only issue in the SSRB relating specifically to metals is the presence of mercury in sediments and fish flesh. However, an evaluation (Tones, 1988) of existing metal values in the basin revealed that values exceeded aquatic life guidelines (CCREM, 1987) for several metals. There is a lack of information on the effect of metals on basin biota; therefore, it is not known whether the metal levels are indeed a concern.

i) Selection of Parameters

Metals initially considered for objectives development are in Tables 4 and 5. They represent all metals analyzed in the basin by Saskatchewan and near the interprovincial border by the Prairie Provinces Water Board.

Table 4. Guidelines, Basin Values and Proposed SSRB Objectives for Aquatic Life Protection

METAL	CCREM GUIDELINES (mg/L)	SASKATCHEWAN SURFACE WATER QUALITY OBJECTIVES (mg/L)	BASIN VALUES (mg/L)	SSRB PROPOSED OBJECTIVES (mg/L)
Aluminum	<0.1[a]		0.04 - 23	
Arsenic	0.05	0.050	L .5 - 18 ug/L	
Barium		1.0	0.009 - 0.46	
Cadmium	0.0013[b]	0.001	L .001 - 0.006	0.001
Chromium	0.002	0.020	L .001 - 0.028	0.01
Copper	0.003[b]	0.01	0.002 - 0.029	0.01
Cyanide	0.005 free	0.01 total	L .1 - 52 ug/L	0.01 total
Iron	0.3	1.0 total, 0.3 diss	0.036 - 14	1.0
Lead	0.004[b]	0.02	0.002 - 0.28	0.02
Mercury	0.001	0.0001	L .02 - 1.65 ug/L	0.0001
Nickel	0.110[b]	0.025[b]	L .001 - 0.034	0.025
Selenium	0.001	0.01	L .001 - 0.008	0.002
Silver	0.0001	0.01	L .001 - 0.003	
Zinc	0.03	0.05	L .001 - 0.96	0.05

[a] pH dependent
[b] hardness dependent

Table 5. Guidelines, Basin Values and Proposed SSRB Objectives for Agricultural Use Protection

METAL	CCREM GUIDELINES (mg/L)		SASKATCHEWAN SURFACE WATER QUALITY OBJECTIVES (mg/L)		BASIN VALUES (mg/L)	SSRB PROPOSED OBJECTIVES (mg/L)	
	Irrigation	Livestock Watering	Irrigation	Livestock Watering		Irrigation	Livestock Watering
Beryllium	0.01, 0.5[a]	0.1	0.1	0.1	L .001 - 0.004	0.1	0.1
Boron	0.5-6.0	5.0	0.5	5.0	L .01 - 0.1	0.5	5.0
Cobalt	0.05	1.0	0.05	1.0	L .001 - 0.006	0.05	1.0
Manganese	0.2		0.2		0.003 - 0.27	0.2	
Molybdenum	0.01	0.5	0.01	0.5	0.005 - 0.016	0.01	0.5
Vanadium	0.1	0.1	0.1	0.1	L .01 - 0.03	0.1	0.1

[a] soil texture dependent

ii) Uses to be Protected

The presence of metals in water affects most water uses (drinking, aquatic life, agricultural, industrial) to various extents. Evaluation of existing (CCREM, 1987) guidelines (as an indication of sensitivity) revealed that the aquatic life use is most sensitive to aluminum, arsenic, cadmium, chromium, copper, iron, lead, mercury, nickel, selenium, and zinc. Objectives will be considered for agricultural use protection for beryllium, boron, cobalt, manganese, molybdenum and vanadium (aquatic life guidelines do not exist for these metals).

iii) Area of Water Quality Objectives Application

The objectives are developed specifically for the SSRB, taking into consideration local water quality conditions (e.g., pH, hardness). The uses which are sensitive to concentrations of each metal are the same throughout the basin, for which reason site-specific objectives were not developed.

iv) Total vs. Filterable Metal Concentrations

The objectives are developed for total metals. Filterable levels provide a better estimate of bioavailability, but not of the total amount potentially available. The total levels are, therefore, more protective. Given that the objectives are not regulatory, but are intended to trigger investigative action, it should not be of concern having a low (or conservative) value. This philosophy is consistent with the total metal data currently collected by the responsible agencies. The United States Environmental Protection Agency is debating the total vs. filterable question. The total objectives (and the supporting monitoring program) should be re-evaluated pending their conclusions and a decision made on the necessity of adjusting the objectives.

v) Proposed Use-Specific Water Quality Objectives

Objectives for Aquatic Life Protection

Aluminum

The CCREM guideline for aluminum is exceeded much of the time in the SSRB. This raises the question: Is the guideline too low, or are aquatic life being adversely affected by high aluminum levels? Aluminum is abundant in all rock types; it is, therefore, naturally present in the basin. It is associated with suspended solids, particularly the clay fraction. Information regarding the toxicity of aluminum under different conditions is inconclusive. Therefore, it is recommended that an objective for aluminum for the SSRB not be developed until more is known about toxicity to aquatic life under basin water quality conditions.

Arsenic

Arsenic levels in the basin are well below the guidelines. The CCREM guideline of 0.05 mg/L is below concentrations known to be toxic to invertebrates and fish, and well below ambient arsenic levels in the basin. It is recommended that an objective for arsenic not be developed for the SSRB unless ambient levels are observed to increase.

Barium

The Saskatchewan objective is 1.0 mg/L (SE & PS, 1988), which is below levels known to be harmful to freshwater fish. Basin values are well below 1.0 mg/L. It is recommended that an objective for barium not be developed unless ambient levels increase.

Cadmium

Most of the cadmium concentration data available for the basin are around the analytical detection limit of 0.001 mg/L, which is also the guideline and the Saskatchewan objective. It is recommended that the Saskatchewan objective be accepted as the basin objective to encourage maintenance and improvement of ambient concentrations. The objective should be re-evaluated if the detection limit changes and/or more information becomes available.

Chromium

Guidelines for chromium are 0.002 mg/L to protect all aquatic life and 0.2 mg/L to protect fish. The 0.002 mg/L guideline is often exceeded in the basin. Weathering of bedrock is the main source of natural chromium in the water. Many anthropogenic sources of the metal exist in the basin as shown by elevated chromium levels in the downstream portion of the basin relative to upstream reaches. It is recommended that 0.01 mg/L be adopted as the chromium objective for the basin, to account for natural levels and to encourage lower chromium concentrations in the downstream reach.

Copper

The copper guideline is exceeded frequently at all sites. Natural sources of copper (a common element in rocks) can be supplemented by anthropogenic sources (effluents, fall-out, algicides, and fungicides). Data do not show copper increases downstream from potential sources; therefore, copper concentrations are likely at natural levels. It is recommended that 0.01 mg/L (SE & PS, 1988) be accepted as the basin copper objective to account for natural copper levels.

Cyanide

The total cyanide levels in the basin are almost all lower then the free cyanide guideline for aquatic life. It is recommended that the Saskatchewan objective 0.01 mg/L (total, SE & PS, 1988) be accepted for the basin.

Iron

The guideline for total iron is 0.3 mg/L. Values in the basin frequently exceed this level. Relatively high concentrations of iron are found in suspended solids. The elevated levels of total iron in the basin reflect naturally high levels of suspended sediment. Although a concentration of 1.0 mg/L is close to the EC_{50} (concentration which causes a lethality response in 50% of test organisms) for the fathead minnow, it is recommended as the total iron objective for the SSRB due to natural levels.

Lead

The lead guideline is exceeded much of the time at all sites, and for some of the data the detection limit is above the guideline. Given the amount of suspended solids in the river and the pH and alkalinity conditions, much of the lead is not likely to be bioavailable. It is proposed that 0.02 mg/L (SE & PS, 1988) be accepted for the SSRB objective to protect fish and to recognize natural occurrences.

Mercury

Levels in the basin are far below guideline levels in water. Mercury bioaccumulates in fish even though concentrations in water are very low. It is recommended that the Saskatchewan Parks, Recreation and Culture guidelines for the consumption of mercury - containing fish, be adopted for the basin. The consumption guidelines indicate the number of meals of fish of various length and given mercury content which can safely be consumed for three reaches of the basin.

The Saskatchewan objective (0.0001 mg/L) for water should also be adopted.

Nickel

Nickel levels are well below the guideline and frequently below the Saskatchewan objective. It is recommended that the Saskatchewan objective of 0.025 mg/L be adopted for the basin.

Selenium

Almost all basin values are at or below the detection limit, which is the same as the guideline. It is proposed that 0.002 mg/L be adopted as the SSRB objective, due to inaccuracies around the detection limit and in recognition of lethality to predatory fish at slightly higher concentrations.

Silver

The silver guideline is an order of magnitude lower than the detection limit, making interpretation of basin values (largely below and at the detection limit) impossible. The toxicity of silver decreases as the water hardness increases; therefore, the relatively hard basin water may be less toxic to aquatic life than the guideline indicates. It is recommended that an objective not be recommended at this time, and that the situation be re-evaluated if or when the detection limit is lowered.

Zinc

Zinc exists in the basin at naturally elevated levels. It is unlikely to be available due to association with suspended sediment given the local pH and hardness conditions. It is recommended that the 0.05 mg/L level

(Saskatchewan objective) be accepted as the basin objective in recognition of natural concentrations (which exceed the guideline) and to protect most aquatic life.

Objectives for Agricultural Use Protection

Beryllium

Basin values are well within the guidelines for irrigation and livestock watering. It is proposed that the guidelines be accepted as the basin objectives.

Boron

Basin values are well below the guidelines. It is proposed that the guidelines be accepted.

Cobalt

Basin values are an order of magnitude below the guidelines. It is proposed that the guidelines be accepted.

Manganese

It is proposed that the 0.2 mg/L level for irrigation use protection be adopted for the basin.

Molybdenum

Almost all values are less than the guidelines. It is proposed that the guidelines be adopted.

Vanadium

Values are an order of magnitude below the guidelines. It is proposed that the guidelines be accepted.

E. Organic Contaminants

The surface waters of the SSRB receive inputs of organic contaminants from agricultural, industrial and municipal sources. Pesticides (herbicides and insecticides) constitute the vast majority of the organic contaminants for which water quality data are available. Industrial and municipal organic substances may occur in the basin, but data are not available to confirm presence or define levels (Saskmont Engineering Ltd., 1987).

i) Selection of Parameters

Table 6 presents the insecticides and herbicides which are thought to or are known to be present in the basin. The list is a composite of pesticides known to be used in Saskatchewan and those which are present or potentially present in the basin. Information for the former is based upon pesticide sales records for the province (Constable, 1987). Information for the latter is drawn from pest control use permits, sales information and an Agriculture Canada pesticide use survey (Saskmont Engineering Ltd., 1987).

It is not necessary, nor is it possible, to develop objectives for all the pesticides present in the basin. Pesticides of most importance are those which are used in the greatest quantities and those which are most toxic, i.e., have the highest potential to adversely impact water uses. Table 7 presents the insecticides and herbicides in high, medium and low concern categories based upon amount of product sold. Absolute amounts cannot be presented here due to the confidentiality of product information.

Table 6. Pesticides Present or Potentially Present in the Basin

Insecticides	Herbicides		
malathion	2,4-D	dalapon	glyphosate
DDT	trillate	diallate	atrazine
terbufos	trifluralin	silvex	sethoxydim
lindane	MCPA	TCA	chlorsulfuron
carbofuran	dicloflop-methyl	diclorprop	paraquat
carbaryl	bromoxynil	diquat	
chlorpyrifos	picloram	flamprop	
deltamethrin	EPTC	mecoprop	
methoxychlor	barban	propanil	
temephos	maneb	difenzoquat	
methoprene	acrolein	dicamba	

Table 7. Relative Concern of Pesticides, Based upon Active Quantity Used in Saskatchewan

Herbicides

High Concern (>300,000 kg)	Medium Concern (100,000 - 300,000 kg)	Low Concern (<100,000 kg)
2,4-D	propanil	TCA
trifluralin	difenzoquat	diclorprop
triallate	dicamba	diquat
MCPA	sethoxydim	flamprop
dicloflop-methyl		mecoprop
bromoxynil		glyphosate
		atrazine
		cyanazine
		chlorsulfuron
		paraquat
		picloram

Insecticides

High concern (>50,000 kg)	Medium Concern (10,000-50,000 kg)	Low Concern (<10,000 kg)
malathion	terbufos	carbaryl
lindane	dimethoate	deltamethrin
carbofuran		methoxychlor
chlorpyrifos		

Pesticides no longer registered (e.g., diallate, DDT) and those not used in 1986 (most recent information available)(e.g., barban, silvex, methoprene) are not included in Table 7.

The toxicities of pesticides to aquatic and mammalian organisms are presented in Table 8. This information is used to identify pesticides of relative concern based upon toxicity, independently of amounts used. The pesticides of most concern are in Table 9.

Pesticides selected for objectives development are 2,4-D, trifluralin, triallate, MCPA, diclofop-methyl, bromoxynil, malathion, lindane, carbofuran and chlorpyrifos. They include all the high concern compounds based upon use and most of the high concern compounds based upon toxicity. Terbufos and methoxychlor are eliminated due to low current usage and no anticipated increase in use.

ii) Uses to be Protected

Pesticides generally have deleterious effects on man, wildlife and aquatic life. By far the most sensitive use, for which pesticide objectives will be developed, is aquatic life. Davis (unpubl. doc.) shows that the aquatic life use is up to 30,000 times more sensitive to pesticides than is the drinking water use (the second most sensitive use).

iii) Area of Water Quality Objectives Application

The sensitivity of aquatic life to pesticides is similar throughout the SSRB, therefore, one set of objectives is proposed for application to the basin.

Table 8 Toxicity of Pesticides to Aquatic and Mammalian Species

Source: Worthing, 1987.

	Aquatic Species	Mammalian Species
Atrazine	LC_{50} (96 hr) trout 4.5-8.8; bluegill 16.0 mg/L	Acute oral LD_{50} rats 1869-3080 mg/kg
Bromoxynil	LC_{50} (48 hr) trout .15 mg/L; catfish 0.63 mg/L	Acute oral LD_{50} rats 190 mg/kg
Carbofuran	LC_{50} (96 hr) trout .28 mg/L	Acute oral LD_{50} rats 8-14 mg/kg, dogs 19 mg/kg
Cyanazine	LC_{50} (48 hr) fish 10 mg/L, minnow 18 mg/L	Acute oral LD_{50} rats 288 mg/kg
Carbaryl	LC_{50} fish 5-13 mg/L	Acute oral LD_{50} rats 850 mg/kg
Chlorpyrifos	LC_{50} (96 hr) trout .003 mg/L	Acute oral LD_{50} rats 135-163 mg/kg, rabbits 1000-2000 mg/kg
Chlorsulfuron	LC_{50} (96 hr) bluegill, rainbow trout >250 mg/L	Acute oral LD_{50} rats 5545-6293 mg/kg
Dimethoate	LC_{50} (96 hr) fish 40-60 mg/L	Acute oral LD_{50} rats 500-680 mg/kg
Diquat		Acute oral LD_{50} rats 231 mg/kg
Delta-methrin	fish not harmed under normal use	Acute oral LD_{50} rats 135-5000 mg/kg
Dichlorprop	LC_{50} (48 hr) bluegill 165 mg/L	Acute oral LD_{50} rats 800 mg/kg
Dicamba	LC_{50} (96 hr) bluegill and trout 135 mg/L	Acute oral LD_{50} rats 1700 mg/kg
Difenzoquat	LC_{50} (96 hr) bluegill 696 mg/L, trout 694 mg/L	Acute oral LD_{50} rats 470 mg/kg
Diclofop-methyl	LC_{50} (96 hr) trout 0.35 mg/L	Acute oral LD_{50} rats 563-693 mg/kg
2,4-D		
Flamprop-methyl	LC_{50} (96 hr) trout 3.3 mg/L	Acute oral LD_{50} rats > 4000 mg/kg
Glyphosate	LC_{50} (96 hr) trout 86, bluegill 120, Daphnia >1000 mg/L	Acute oral LD_{50} rats 5600 mg/kg
Lindane		
Linuron	LC_{50} (96 hr) bluegill and rainbow 16 mg/L	Acute oral LD_{50} rats 4000 mg/kg
MCPA		Acute oral LD_{50} rats 700 mg/kg
Malathion	LC_{50} (96 hr) bluegill .103, lgemth bass .285 mg/L	Acute oral LD_{50} rats 2800 mg/kg
Maneb	LC_{50} (48 hr) carp 1.8 mg/L	Acute oral LD_{50} rats 6750 mg/kg
Mecoprop		Acute oral LD_{50} rats 930 mg/kg
Methoxychlor	LC_{50} (24 hr) rainbow .052, bluegill .067 mg/L, Daphnia .00078 mg/L	Acute oral LD_{50} rats 6000 mg/kg
Paraquat	LC_{50} (96 hr) rainbow 32, brown trout 2.5-13 mg/L	Acute oral LD_{50} rats 150 mg/kg
Propanil	LC_{50} (48 hr) carp 13, goldfish & Jap. killifish 14 mg/L, Daphnia 4.8 mg/L	Acute oral LD_{50} rats 1285-1483 mg/kg
Picloram	LC_{50} (96 hr) rainbow 19.3, fathead minnow 55.3 LC_{50} (48 hr) Daphnia 50.7 mg/L	Acute oral LD_{50} rats 8200 mg/kg
Sethoxydim		Acute oral LD_{50} rats 3200 mg/kg
Terbufos	LC_{50} (96 hr) bluegill .004, trout .01 mg/L	Acute oral LD_{50} rats 1.6-5.4 mg/kg
Trifluralin	LC_{50} (96 hr) bluegill fingerlings .089 mg/L	Acute oral LD_{50} rats >10,000 mg/kg
Triallate	LC_{50} (96 hr) bluegill 1.3 mg/L, trout 1.2 mg/L	Acute oral LD_{50} rats 1675-2165 mg/kg

Table 9. High Concern Pesticides, Based Upon Toxicity

chlorpyrifos
terbufos
methoxychlor
trifluralin
malathion
bromoxynil
carbofuran
diclofop-methyl

iv) Proposed Use-Specific Water Quality Objectives

The pesticides selected for objectives development are presented in Table 10, along with existing guidelines, criteria and basin values. The drinking water guidelines, for which most work has been accomplished to date, are presented here as a basis for comparison. The aquatic life guidelines are an essential foundation for developing the basin-specific objectives. The criteria are useful references where guideline information does not yet exist. The basin values summarize the SSRB data that exist for each pesticide.

Information is, at best, sparse. Aquatic life guidelines only exist for 2,4-D and lindane. Basin values exist for eight of the ten pesticides, but are very limited in time, location and representation. Even criteria information, the most basic level of information on the pesticides, is missing for seven of the ten pesticides.

An aquatic life guideline will be available for carbofuran in 1989. Draft guidelines will be available for diclofop-methyl, trifluralin and triallate by the end of 1989. MCPA and bromoxynil guidelines will be proposed by 1990. Malathion and chlorpyrifos guidelines will be considered at a later date.

Guideline preparation involves extensive evaluation of the literature,

Table 10. Guidelines, Criteria, Basin Values and Proposed SSRB Objectives for Organic Contaminants

Herbicides	Drinking Water Guidelines	Aquatic Life CCREM Guidelines	EPA Criteria	Basin Values	SSRB Proposed Objectives for Aquatic Life
2,4-D	0.1 mg/L	4 ug/L		0.004-0.71 ug/L, 7 ug/L[a], 9.4 ug/L[b]	2 ug/L
trifluralin				<d.1. 0.01, 0.001 ug/L	Below accepted d.1[c]
triallate	0.23 mg/L			0.01 ug/L Lake Diefenbaker	Below accepted d.1
MCPA				<d.1., 0.02 - 10.7 ug/L[b], 0.67 ug/L Lake Diefenbaker	Below accepted d.1
diclofop-methyl	0.009 mg/L			max 6.1 ug/L[b], <d.1 0.01 ug/L	Below accepted d.1
bromoxynil	0.005 mg/L			max 2.0 mg/L[b]	
Insecticides					
malathion	0.19 mg/L		0.1 ug/L chronic		Below accepted d.1
lindane	0.004 mg/L	0.01 ug/L	2.0 acute, 0.08 ug/L chronic	0.001 - 0.009 ug/L, 0.03 ug/L[a]	0.01 ug/L
carbofuran	0.09 mg/L			0.0033 ug/L Swift Current Creek	Below accepted d.1
chlorpyrifos	0.09 mg/L		0.083 ug/L acute, 0.041 ug/L chronic		Below accepted d.1

[a] City of Saskatoon
[b] Irrigation water
[c] Below accepted detection limit adopted as an "interim" objective.

including physical/chemical properties, ambient environmental concentrations, fate, persistence and toxicology. It is a time-consuming process that is beyond the scope of this study. It is felt that any objectives based upon basin values and existing documentation (and no guideline), would neither be scientifically sound nor have the credibility and acceptance necessary for the objectives to be effective. It is, therefore, recommended that objectives be developed for the pesticides as soon as the relevant guidelines become available.

The aquatic life guideline for 2,4-D is 4 ug/L. Ambient values vary from 0.004 to 0.71 ug/L, while single values of 7 ug/L and 9.4 ug/L have been recorded in unique situations. It is proposed that the objective for 2,4-D be 2 ug/L.

The aquatic life guideline for lindane is 0.01 ug/L. Ambient levels vary below this level, from 0.001 - 0.009 ug/L. An isolated value of 0.03 ug/L was observed in an unique situation. It is proposed that the guideline of 0.01 ug/L be accepted as the basin objective for lindane. Given the ambient levels, the Saskatchewan objective (0.1 ug/L) appears to be too lenient.

It is proposed that an interim objective of "below accepted detection limits" be adopted for the remaining eight pesticides in Table 10 until guidelines and other information become available.

V. SUMMARY OF PROPOSED WATER QUALITY OBJECTIVES AND RECOMMENDATIONS

The water quality objectives proposed for the SSRB are summarized in Table 11. These were developed by the Water Quality Technical Committee and, in their judgement, present the best values, based on current knowledge, for the protection and enhancement of water quality for present and potential water uses.

The objectives will not serve their intended uses merely by being recommended by the Committee. It is essential that monitoring plans be developed to observe compliance with the objectives and to trigger remedial action, if required, in the case of exceedences.

The objectives must be reviewed, on a routine basis, in order to incorporate new scientific information as it becomes available and to ensure that the objectives are protecting water uses. Of most importance, the responsible agencies must agree to work towards the achievement or maintenance of the water quality objectives.

It is recommended that monitoring plans be developed and implemented, that a mechanism be established for the ongoing review of the objectives, and that the responsible jurisdictions ratify the proposed water quality objectives.

Table 11. Summary of Proposed SSRB Objectives

Parameter		Proposed Use - Specific Objectives			
		Irrigation	Livestock Watering	Contact Recreation	Aquatic Life
Salinity					
	TDS	500 mg/L	1000 mg/L		
	SAR	< 3			
Bacteria					
	Total Coliform	1000/100 ml			
	Fecal Coliform	100/100 ml		200/100 ml	
Metals					
	Aluminum				
	Arsenic				0.05 mg/L
	Barium				1.0 mg/L
	Beryllium	0.1 mg/L	0.1 mg/L		
	Boron	0.5 mg/L	5.0 mg/L		
	Cadmium				0.001 mg/L
	Chromium				0.01 mg/L
	Cobalt	0.05 mg/L	1.0 mg/L		
	Copper				0.01 mg/L
	Cyanide				0.01 mg/L (total)
	Iron				1.0 mg/L
	Lead				0.02 mg/L
	Manganese	0.2 mg/L			
	Mercury				0.0001 mg/L, [1]
	Molybdenum	0.01 mg/L	0.5 mg/L		
	Nickel				0.025 mg/L
	Selenium				0.002 mg/L
	Silver				0.005 mg/L
	Vanadium	0.1 mg/L	0.1 mg/L		
	Zinc				0.05 mg/L
Organic Contaminants					
	2,4-D				2 ug/L
	Lindane				0.01 ug/L

Nutrients	Soluble Reactive Phosphorus	Total Phosphorus	Total Ammonia
Lake Diefenbaker			
at Saskatchewan Landing		0.061 mg/L	
at Herbert		0.059 mg/L	
at Riverhurst		0.058 mg/L	
at Douglas		0.058 mg/L	
at Danielson		0.058 mg/L	
Mainstem South Saskatchewan River			
upstream of Lake Diefenbaker		[2]	CCREM[3]
downstream of Lake Diefenbaker	<0.005 mg/L		CCREM
Swift Current Creek	<0.005 mg/L		
SSEWS Reservoirs			
Broderick		<0.03 mg/L	CCREM
Brightwater		<0.03 mg/L	CCREM
Blackstrap		<0.03 mg/L	CCREM
Bradwell		<0.05 mg/L	CCREM
Zelma		<0.03 mg/L	CCREM
Dellwood		<0.03 mg/L	CCREM
Little Manitou		<0.05 mg/L	CCREM

1 See provincial guidelines for fish consumption.
2 Maintain oxygenated conditions at sediment-water interface.
3 CCREM, 1987. Chapter 3-19. Maintain total ammonia at guideline levels.

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