

Contents

I	AN INTRODUCTION TO THE SOUTH SASKATCHEWAN RIVER BASIN	5
I.1	The Saskatchewan River Basin	5
I.1.i	Water Use	7
I.2	Drainage Basins of the Saskatchewan River	10
I.3	Eco-sites and Eco-regions	12
I.3.i	The Prairie Ecozone	13
I.3.ii	The Aspen Parkland Ecoregion	13
I.3.iii	Moist Mixed Grassland Ecoregion	14
I.3.iv	Mixed Grassland Ecoregion	14
I.3.v	Cypress Upland Ecoregion	14
I.3.vi	Fescue Grassland	15
I.3.vii	The Montane Cordillera Ecozone	15
I.3.viii	Eastern Continental Divide Ecoregion	16
I.3.ix	Northern Continental Divide Ecoregion	16
I.3.x	Boreal Plains Ecozone	17
I.3.xi	Boreal Transition Ecoregion	17
I.3.xii	Western Alberta Upland	18
I.4	Dams and Reservoirs	18
I.5	Geology and Soils	19
I.5.i	Aquifers and Groundwater	23
I.6	The Watershed	28
I.6.i	South Saskatchewan River	30
I.6.ii	Effective Drainage Area: South Saskatchewan River	33
I.7	Hydrology of the South Saskatchewan River	35
I.7.i	Natural Flow Hydrology (Upstream of Gardiner Dam)	37
I.7.ii	Effect of Gardiner Dam on River Hydrology	38
II	PROJECT OVERVIEW	41
II.1	A Brief Introduction to the Research	41
II.1.i	The primary objectives of this study are to:	42
II.2	Study Area	43
II.3	Research Approach	45
II.4	Water Quality Sampling Locations	46
II.5	Water Quantity (Flow) Monitoring Stations	51
II.6	Water Quality Parameters	52
III	UNDERSTANDING WATER QUALITY	56
III.1	Chemical Constituents of Surface Water	56
III.2	Determining “Water Quality”	57
III.2.i	Water Quality Variability	58
III.2.ii	Water Quality Monitoring and Assessment	59
III.3	Threats to Water Quality	59
III.3.i	Urban Development and Wastewater Effluent	61
III.3.ii	Population Density	63

III.3.iii	Agricultural Activity.....	64
III.3.iv	Mining and Petroleum Production.....	69
III.3.v	Energy Production.....	78
III.3.vi	Industrial Manufacturing and Processing	79
III.3.vii	Landfills	80
III.3.viii	Summary of Contaminant Sources	83
IV	CHARACTERISTICS OF WATER QUALITY IN THE SOUTH SASKATCHEWAN RIVER ...	85
IV.1	Water Quality Time Series for the SSRB	85
IV.1.i	Monitoring Gaps	85
IV.1.ii	Upstream to Downstream Changes.....	88
IV.2	Water Quality Seasonality	96
IV.3	Water Quality and River Hydrology (Flow).....	102
IV.3.i	Testing Flow – Water Quality Relationships.....	104
IV.3.ii	Water Quality Parameters That Are Related to Flow.....	121
V	WATER QUALITY BENCHMARKING FOR THE S. SASK. RIVER IN SK.....	122
V.1	Determining Water Quality Baselines for Rivers.....	122
V.1.i	Using Pristine Reference Sites (Method 1).....	123
V.1.ii	Modeling Using Reference Streams (Method 2)	124
V.1.iii	Statistical Approaches Using Existing Data (Method 3).....	124
V.1.iv	Biological, Toxicological, or Other Thresholds (Method 4).....	125
V.1.v	Baseline Assessment Methods Used for This Study	126
V.2	Water Quality Benchmarking Using Thresholds	127
V.2.i	Threshold Selection and Application	128
V.2.ii	Summary of Guideline Exceedances.....	131
V.3	Water Quality Benchmarking Using Trend Analysis.....	157
V.3.iii	Summary of Trend Analysis.....	163
VI	LAND USE RISK ASSESSMENT	165
VI.1	General Land Use	166
VI.1.i	Delineating Land Use by Drainage Area.....	166
VI.1.i	Land Use in the South Sask. River Basin (in Saskatchewan)	169
VI.1.i	Summary Table for Land Use Along the SSR	176
VI.2	Urban Land Use and Wastewater	179
VI.2.i	Land Use Mapping Around the City of Saskatoon	179
VI.2.ii	Summary of Land Use Change – City of Saskatoon (1971-1986).....	182
VI.2.iii	Municipal Effluent	183
VI.3	Agriculture	184
VI.3.i	Agricultural Census Data	184
VI.3.ii	Phosphorus Risk Index Mapping.....	198
VI.4	Population Density	202
VI.5	Mining and Oil & Gas Extraction	205
VI.6	Energy Production.....	209
VI.7	Industrial Activity	209
VI.8	Landfills and Municipal Lagoons.....	209

VII	WATER QUALITY MONITORING PROGRAM DESIGN	214
VII.1	Water Quality Monitoring Program Design.....	214
VII.1.i	What is Water Quality Monitoring?.....	215
VII.1.ii	The Purpose of Water Quality Monitoring	216
VII.1.iii	Water Quality Parameter Variability	219
VII.2	Important Considerations for Water Quality Monitoring Program Design	223
VII.2.i	Setting Monitoring Objectives.....	224
VII.2.ii	Program Design	225
VII.2.iii	Sampling Site Selection and Sampling Frequency.....	227
VII.2.iv	Water Quality Parameter Selection	229
VII.2.v	Case Studies: Newfoundland and New Zealand.....	231
VII.2.vi	Case Study: New Zealand.....	232
VII.3.vii	Case Study: Newfoundland and Labrador	235
VII.3	Current Water Quality Monitoring in Saskatchewan.....	239
VII.3.i	Monitoring Agencies.....	239
VII.3.ii	Monitoring GAPS Analysis.....	245
VII.4	Recommendations	260
VII.4.i	Recommended Sampling Locations	261
VII.4.ii	Sampling Frequency	285
VII.4.iii	Water Quality Parameters	288
	Protection of Aquatic Ecosystem Health	290
	Understanding Overall Water Quality.....	291
	Provincial and Federal Monitoring Programs	292
VII.4.iv	Sampling Methods and Protocol.....	294
VIII	BENEFICIAL MANAGEMENT PRACTICES FOR WATER QUALITY RISK MITIGATION	296
VIII.1	Agricultural Beneficial Management Practices.....	297
VIII.2	Urban Beneficial Management Practices.....	304
VIII.3	BMP Focus Areas for the South Saskatchewan River Basin.....	307
VIII.3.i	Nutrient Runoff from Agricultural Activity.....	307
VIII.3.ii	Contamination from Stormwater Discharge	309
VIII.3.ii	Wetland Retention	309
IX	REFERENCES	310