Saskatchewan Watershed Authority

CLIMATE CHANGE ADAPTATION
Cost-benefit Analysis of Adaptation Options in Water Use

Saskatchewan Watershed Authority

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Glossary and Abbreviations

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Glossary and Abbreviations

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

CBA	Cost Benefit Analysis
EI	Economic Instrument
ES	Ecosystem Services
FTE	Full-time Equivalent
GHG	Greenhouse Gas
LCD	Litres per capita per day
LLID	Luck Lake Irrigation District
MBI	Market-based Instrument
NPV	Net Present Value
PCCP	Pre-stressed Concrete Cylinder Pipe
RID	Riverhurst Irrigation District
PRAC	Prairie Regional Adaptation Collaborative
Rescan	Rescan Environmental Services Ltd.
SSEWS	Saskatoon South East Water Supply
SSRID	South Saskatchewan River Irrigation District
SWA	Saskatchewan Watershed Authority
WCEP	Water Conservation, Efficiency, and Productivity
WID	Western Irrigation District (Province of Alberta)
WUE	Water Use Efficiency

1. Introduction

1. Introduction

1.1 STUDY BACKGROUND

The Saskatchewan Watershed Authority (SWA) is working towards the Government of Saskatchewan's goal of security by enhancing the knowledge of climate change adaptation decision-making related to water resource management. Work undertaken as part of the Prairie Regional Adaptation Collaborative (PRAC) on Water Conservation, Efficiency, and Productivity (WCEP) in Saskatchewan (Rescan 2012) provided the first step in integrating WCEP within select water use sectors, and identified over 20 options to mainstream water conservation. There is a need to conduct an economic analysis of these water conservation options to further inform decision-making with respect to the adoption of specific WCEP policy interventions.

Based on the results of the previous WCEP study (Rescan 2012), there are a number of options and strategies that would be recommended for economic analysis at this time. This includes two options and strategies for the Municipal Sector and two for the Irrigation Agriculture Sector. In the Municipal Sector, further exploration of the economic costs and benefits or cost-effectiveness of implementing alternative water pricing structures and improving water use metering and reporting is recommended. Similarly in the Irrigation Agriculture Sector, understanding the net economic benefits or efficiencies of alternative water pricing structures and improved water metering and reporting systems is important. These additional analyses will help inform provincial government policy and program decision-making regarding WCEP and climate change adaptation mainstreaming.

1.2 THE BENEFITS OF WATER

The benefits of water to human well-being consists of both market and non-market aspects (e.g., Young 2005). When water is used as a direct input to economic activities, such as crop production, its use can be measured and the economic value can be captured in markets. Water is also used as an input to produce a number of other benefits to human well-being that do not have markets, such as the provision of most ecosystem services (ES; MA 2005). Ecosystem services are natural processes that provide goods and services that are valued by humans, such as groundwater recharge, provision of quality water, and support for biological productivity, among others. With respect to ES, the good or service provided is often external to the economic market system because there is no "ownership" of the ES or exclusion of who can or cannot benefit (i.e., established property rights).

Fees established for water have been used mainly to cover cost of diverting, storing, and conveying water from source to where it is needed. The water itself was considered a "free" provision of nature (e.g., Percy 1996). Because water is often viewed as being free, this has led to management decisions that do not factor in the true costs, resulting in quality and supply issues. Ultimately, management of the resource that is not based on a full-cost accounting has led to the loss of benefits, requiring investment in capital and technology to restore benefits to their desired levels (e.g., Percy 1996; De Groot et al. 2009).

1.3 ECONOMIC ANALYSIS AND FISCAL REFORM

1.3.1 Estimation of Costs and Benefits

A cost-benefit analysis (CBA) can be used to establish whether the identified options and strategies for integrating WCEP into targeted sectors will yield positive social returns. In other words, is the policy intervention a wise social investment? This is determined by comparing the total estimated value of social benefits to the expected costs associated with the implementation of the options and strategies. A key component of the analysis is the calculation of the net present value (NPV), which is defined as the current equivalent net value of the options and strategies (e.g., Tietenberg 2006). In a simplified depiction, the NPV over an infinite time period is calculated according to:

$$\boldsymbol{NPV} = \frac{(\boldsymbol{B}-\boldsymbol{C})}{\boldsymbol{i}} = \frac{\boldsymbol{NV}}{\boldsymbol{i}} \qquad (1)$$

where *C* is the costs, *B* is the benefits, *i* is the discount rate, and *NV* is the net value.

A positive NPV indicates economic viability and benefit to society, and a negative NPV indicates that the investment is not in society's best interests (i.e., financial resources could best be put to other policy interventions). A full accounting of all relevant social costs and benefits is important for the analysis to be comprehensive. This includes the consideration of the direct costs and benefits currently captured by the market and the indirect costs and benefits that are not directly accounted by the market (e.g., ES values); in certain circumstances, other non-market values are also important to consider (e.g., existence and bequest values associated with certain environmental attributes). A number of different economic valuation methods can be applied to value the various components depending on the requirements of the specific CBA.

Approaches and methods for applying a CBA are well established in policy assessment and are supported by a breadth of literature. For Canadian government policy decisions, the method is guided by the recommended federal approach for the assessment of regulatory proposals (Treasury Board of Canada 2007).

1.3.2 Estimation of Cost-effectiveness

A rigorous CBA approach presumes that a comprehensive range of costs and benefits associated with a given intervention are known and measurable, and that the policy options being considered are not overly restricted. However, with respect to the application to government policy questions, a cost-effectiveness analysis is often more appropriate. Cost-effectiveness (CE) analysis addresses efficiency in relation to management objectives considered under a constrained range of intervention options and for those values that can reasonably be measured. It is used when there is a pre-established desired policy outcome and one wants to identify the most cost-effective means to achieve this outcome without a full assessment of the benefits.[1] This is typically the case when a management objective is determined based on information from multiple sources (e.g., from the biological or physical sciences, or socio-political considerations) not on an analysis of economic efficiency.

1.3.3 Fiscal Reform

Fiscal reform is the changing of government policy and spending to achieve a given socially-beneficial goal. Environmental fiscal reform focuses on measures to internalize ES values into economic decision-making to support the achievement of maximum social benefits.

The goal of fiscal reform via adoption of targeted WCEP-promoting policies or activities by the Government of Saskatchewan is to ensure sustainable water supplies for ecosystem health and

[1] For example, a cost-effectiveness analysis would be appropriate to determine the least-cost means to achieve a pre-determined water use reduction target for a particular sector. Alternatively, a CBA would be appropriate to determine if the water use reduction target itself was a desirable policy intervention from a net social benefit perspective or if government efforts would be better applied elsewhere.

continued economic growth for the Province. The cornerstone of fiscal reform is scientifically-based information for decision-makers. Fiscal reforms targeted at water use have been implemented in a number of jurisdictions. Specifically as it applies to water use in a rural, agricultural context, advances have been made in the Province of Alberta, Australia, and the US with respect to water policy that diverges from a traditional command-and-control approach.

1.3.4 Economic Instruments

Economic instruments (EIs), also known as market-based instruments (MBIs), have been promoted as an alternative to command-and-control water management (Bjornlund et al. 2007). The aim of using EIs is to use the incorporate the value of the water, beyond infrastructure and conveyance, into the market creating an incentive to use water for higher-value uses and conserve supplies (Bjornlund et al. 2007). The EIs commonly used in water management reform to increase water use efficiency (WUE) and conservation are presented in Table 1.3-1.

Table 1.3-1. Economic Instrument Approaches Used in Water Management

EI Approach for Water Management	How EIs Can Achieve Policy Goals
Trading of Water Rights	Rights of use and/or ownership can be transferred between water users creating value for the property right and an incentive to conserve water.
Water Fee Changes	Changes to water fee structure to include the lost benefit of water for alternate uses and addressing environmental harm, thereby creating an incentive for conservation.
Legal Liability and Insurance	High cost of liability to other water use sectors and the environment, and/or insurance policies carrying high premium cost or loss of coverage for impact to other use sectors and the environment creating incentive to conserve water and avoid environmental impact.
Tradable Permits for Water Use	Provides a means for high volume water users to obtain water while overall water allocation limits are met, promoting conservation.

Source: Adapted from Cantin et al. (2005).

The ability of EIs to achieve water conservation is debated. The effectiveness of implementing EIs as part of fiscal reform are unique to location and dependant on the knowledge of the users, level of operation between user sectors, and presence of supportive institutional frameworks (e.g., PRI 2005; Bjornlund et al. 2007). In other words, there are a number of situational factors that can distort the functioning of EIs that need to be taken into account to ensure the efficacy of the policy intervention.

1.4 STUDY PURPOSE AND OBJECTIVES

The purpose of the study is to provide an economic analysis of options to mainstream WCEP within two key water use sectors – the Agriculture Irrigation Sector, and the Municipal Sector. An understanding of the economic benefits and costs associated with WCEP interventions will help inform both the development of water conservation and climate change adaptation policy and programming decisions, and the selection of appropriate measures for benchmarking and monitoring of intervention performance. Ultimately a thorough CBA or CE analysis is desirable; however, given the paucity of available secondary information and early development of the policy options, only a partial analysis was possible within the scope of this study.

For the Agriculture Irrigation Sector, the economic analysis is to focus on the following options:

1. Implementation of alternative water pricing structures; and
2. Implementation of a water metering and reporting structure.

For the Municipal Sector, these are to include:

1. Implementation of alternative water pricing structures; and
2. Improvements in the effectiveness of water metering.

All policy interventions were defined at a high level and are presented as hypothetical case studies. This study provides an overview of the potential benefits and costs of increasing water efficiency and conversation using various examples based on available secondary information, feedback from stakeholder engagement sessions, and published literature. The study is organized as follows. Section 2 provides background on the study approach and methods. Section 3 provides the results of the analysis for the use of water pricing or water metering to increase conservation in the Irrigation Agriculture Sector. Section 4 provides the results of the analysis for use of water pricing or water metering to increase conservation in the Municipal Sector. Section 5 provides a summary and recommendations for future work.

2. Approach and Methods

2. Approach and Methods

2.1 SELECTION OF POLICY INTERVENTIONS

The Government of Saskatchewan is looking for options beyond traditional command-and-control policy to implement WCEP. The EI policy options most commonly used for water management reform to increase water conservation in the Irrigation Agriculture Sector are water markets and water pricing (Bjornlund et al. 2007), and to a lesser extent water metering (Richards et al. 2009). Each method has shown promise in select regions to be able to move water to higher value uses and increase conservation (Bjornlund et al. 2007; Richards et al. 2009). Municipal Sector EI options generally include pricing and metering to provide cost incentives to reduce water use alongside rebate and education programs to encourage adoption of lower use technology (Tasa 2012; SWA 2010).

The policy interventions were defined for this study from: 1) direction provided by SWA on those potentially of interest for initial exploration; 2) consideration of feedback on priorities and interests of stakeholders in the Irrigation Agriculture Sector and Municipal Sector (Rescan 2012); and 3) information from other jurisdictions on similar initiatives. For the purposes of this study, all policy interventions were defined at a high level and are presented as hypothetical case studies. The defined policy options should not be interpreted as being selected. Development of policy option details will require additional work by the Government of Saskatchewan in consultation with sector stakeholders.

2.2 INFORMATION SOURCES

Information on the cost and benefit of policy outcomes is sparse in Canada (PRI 2005). As such, information sources from other jurisdictions are used, including journal articles, non-government organization (NGO) reports, and reports produced by the governments of Saskatchewan and Alberta. Various secondary information sources are used to characterize and quantify water use, and to provide prices (values) for individual cost and benefit components associated with each identified policy intervention; these sources are cited in the report where utilized. The transferability of information from other studies to this study was assessed to ensure findings of previous work fits to the context of this study.

2.3 CALCULATION OF COSTS AND BENEFITS

The calculation of costs and benefits for the Irrigation Agriculture Sector and the Municipal Sector policy options using water metering and water pricing require data on each applicable cost and benefit component for each scenario, the analysis timeframe, and the discount rate. Eq. (1) is then used to determine the NPV for each option, where feasible, to evaluate the net cost and if there is a net social benefit, as appropriate, associated with the policy. Given the paucity of available secondary information and early development of the policy options, only a partial analysis was possible within the scope of this study.

2.3.1 Timeframes and Discounting

The choice of discount rates and timeframes for analysis are two sources of uncertainty in economic analysis. When selecting timeframes, it is important for the timeframe to be long enough to encompass all potential costs and benefits, including those whose value changes over time. In cases where it is not possible to determine appropriate timeframes from available information, an infinite timeframe is recommended. In other cases, where specific information is available to determine a timeframe, it should be selected to reflect the appropriate period in light of the available information and the policy intervention being considered.

The timeframe selected for this study is 10 years. This was selected because it is felt to encompass the time required to implement the policy interventions in question, and all main associated costs and benefits will have accrued.

There are a number of items to consider when choosing discount rates. Discounting is used to meaningfully compare values over time, and the selection of discount rates is a subject of debate in the literature, particularly when valuing environmental assets (e.g., Portney and Weyant 1999). Discount rates are recommended to be selected considering:

- the return on investment capital;
- the social rate of time preference;
- increases in consumption over time; and
- negative effects on environmental assets.

Each of these considerations influences the discount rate differently. The return on investment capital, which recognizes the opportunity costs associated with each investment, typically leads to greater discount rates (e.g., 6% or greater). The social rate of time preference, which recognizes trade-offs between present and future well-being, typically results in low discount rates (e.g., between 0 and 1%). Increases in consumption over time, which assumes that future generations are better off and will consume more, typically results in minor increases in discount rates (e.g., between 1 and 2%). Negative effects on environmental assets, which assume that economic activity has negative environmental consequences and thus reduce social returns, typically result in very low discount rates (e.g., approaching 0%).

For this study, a range of discount rates was selected to capture the above considerations. Specifically, rates of 2, 5 and 8% were selected for the analysis (see Section 2.4).

2.4 SENSITIVITY ANALYSIS AND SCENARIOS

Given the uncertainties associated with estimating costs and benefits, including the chosen discount rate, sensitivity analysis and scenario-based assessment are adopted. Sensitivity analysis typically involves calculating economic values based on a range of values. To fully capture the range of all likely potential values, three estimates are typically used: the mean or median; a highest likely or reasonable estimate; and a low likely or reasonable estimate. In some cases, these can be determined statistically (e.g., based on standard deviations), but in other cases, where statistical information is not available, professional judgement can be applied.

Scenario assessment typically involves the clear definition of potential conditions (e.g., social, economic, and environmental) in which the costs and benefits are embedded in relation to assumed baseline conditions. Scenario exploration is used to understand the range of potential values when the underlying assumptions of system structure used in calculations are likely to change in a number of foreseeable, yet unpredictable ways. This approach is common in a number of fields (e.g., risk management) and is especially relevant in the context of climate and environmental change.

For this study, the use of scenarios was explored for the calculation of costs and benefits, as appropriate, for both the Irrigation Agriculture Sector and the Municipal Sector in order to determine the sensitivity of the results to assumption uncertainties. However, because policy options are currently defined in general terms, it is felt that selection of a range of values for individual cost and benefit components was not appropriate. Instead, the analysis focused on two main scenarios for comparison: i) no change to water use; and, ii) 30% decrease in water use. The two scenarios are applied to each sector to achieve the objectives of the economic analysis. The selection of a 30% reduction in water use is derived from Alberta's Water for Life Strategy water use efficiency goal (AESRD 2003, 2008), and literature on the potential savings of installing meters and using appropriately tiered water pricing (McNiell and Tate 1991).

3. Irrigation Agriculture

3. Irrigation Agriculture

3.1 CURRENT SITUATION

Current irrigation development for agriculture in Saskatchewan is mainly fed from the Lake Diefenbaker system, lying in the area south of Saskatoon and north of Swift Current and Moose Jaw. In total, there are nine Irrigation Districts (Table 3.1-1) varying in size from approximately 1,000 to 35,500 acres of total irrigated land. In addition, the Saskatoon South East Water Supply (SSEWS) provides irrigation to approximately 14,500 acres of land; irrigators pump directly out of the main canal.

Table 3.1-1. Existing Irrigation Development, 2010

Irrigation District	Area Irrigated (acres)	Potential Additional Infill (acres)	Infrastructure
South Saskatchewan River	35,469	24,500	Canal
Riverhurst	11,442	11,000	Pressurized mainline
Luck Lake	10,152	9,000	Pressurized mainline
Hillcrest	3,497	nd	Canal
Macrorie	2,471	nd	Canal
Grainland	2,141	nd	-
Brownlee	1,893	nd	-
Thunder Creek	1,422	nd	-
River Lake	985	nd	-

Note: Potential additional infill is defined as the additional amount of land that could be irrigated.
nd = no data.

The three largest Irrigation Districts off of Lake Diefenbaker are the South Saskatchewan River Irrigation District (SSRID), Luck Lake Irrigation District (LLID), and Riverhurst Irrigation District (RID). Water delivery infrastructure currently consists of canals (lined and unlined) and pressurized mainline (Pre-stressed Concrete Cylinder Pipe, or PCCP; Table 3.1-1).

The SSRID by far serves the largest area. Water is delivered through two main canals (M1 and M2, approximately 21 km and 27 km in length, respectively) and a number of lateral canals and drains (approximately 450 km in total length). About 26 km of canal is lined with surface liner, while about 107 km is lined with buried liner. In total, there are currently approximately 317 km of unlined canals in the SSRID. Small lateral canals are increasingly being replaced with gravity pipelines. Of the total 35,469 acres currently being irrigated, approximately 2,030 acres are by gravity and 33,440 acres by sprinklers. In total, there are approximately 100 water users irrigating about 340 parcels of land.

User fees are currently charged by the Irrigation Districts. The SSRID charges $23.45/acre plus $3.75/acre-ft (2010 prices). RID and LLID charge users $60/acre-ft (2010 prices).

An important issue within the Irrigation Agriculture Sector is underdeveloped infrastructure that leads to significant loss of water in the system. Unlined irrigation canals potentially lose 20 to 50% of the water flow to seepage (Hill 2000). For example, southern Alberta irrigation districts lost an estimated 9,100 Dam^3 (7,330 acre-feet), about 70 m^3/acre, of water to seepage irrigating around 1.23 million acres in 1999 (Iqbal et al. 2002; AARD 2012). Rehabilitation of irrigation canals in Alberta is an ongoing effort to reduce or halt water seepage losses (WID 2012). Rehabilitated canals in the Alberta's Western Irrigation District (WID) have virtually no seepage losses, thereby increasing water flow capacity to supply increasing demands (WID 2012). Similar efforts have been applied to some SSRID irrigation works to increase capacity for growing demand and reduce seepage losses (AgSask 2012a).

The cost of canal rehabilitation varies depending on the work done. As a point of reference, the cost for canal rehabilitation in Alberta's WID in 2011 was approximately $650 to $700/m and the cost of replacing old canals with pipelines was approximately $187 to $240/m (WID 2012)[2]. Using these figures, Table 3.1-2 presents the estimated cost summaries of rehabilitating canals or conversion to pipes for the unlined canals in the SSRID[3].

Table 3.1-2. Total Estimated Cost of Seepage Control Options for Unlined Canals in the SSRID

Seepage Control Option	Estimated Cost ($/km)[1,2]	Total Estimated Cost ($)[3]
Rehabilitating canals	$675,000	$214 million
Conversion to pipes	$213,500	$77.0 million

[1] Based on average cost of canal rehabilitation for the WID in Alberta (WID 2012).
[2] Based on average reported cost of converting a canal to a pipeline for the WID in 2011 (WID 2012).
[3] Based on 317 Km of reported unlined canals in the SSRID.

3.2 GUIDANCE FROM SECTOR STAKEHOLDER ENGAGEMENT

Previous research (Rescan 2012) engaged stakeholders in the Irrigation Agriculture Sector with the purposes to:

- understand participants' perceptions of WCEP;
- complete a high-level analysis of sector-specific vulnerabilities, opportunities, and constraints related to WCEP; and
- identify a preliminary list of options and strategies that could be further studied for integrating WCEP into targeted sectors.

The results of workshops with stakeholders provided some guidance on potential policy interventions. This is discussed below.

3.2.1 Converting Ditches to Pipes or Rehabilitating Ditches

A potential program that was highlighted by stakeholders would support the conversion of irrigation water delivery systems from open ditches and canals to pipes or, in cases where pipes are not possible, lined ditches and canals. Currently, the cost of undertaking this conversion was regarded as the major inhibitor. Participants also noted how this type of program requires long-term funding, as completing the necessary upgrades is a time-consuming and iterative process. Other co-benefits, in addition to WCEP improvements, from conversion include salinity prevention and reduced maintenance costs.

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[2] Lower cost alternatives are available such as rehabilitation using soil compaction that reduces seepage by 85 to 90% with a cost of approximately $5/m depending on soil conditions (Burt 2008). However, canals with compacted soil require regular maintenance to prevent erosion.
[3] The figures are reported as total present costs, assuming all costs would be incurred in the current year (i.e., costs are not discounted). This also assumes that all canals are, on average, the same size as the canals rehabilitated in Alberta. Canals of varying sizes would have different costs to rehabilitate.

3.2.2 Improving the Collection of Water Use Data

Participants highlighted the need to improve the collection of water use data to inform water management and provide benchmarks for WCEP planning. It is believed likely that this would require legislative and regulatory changes to water allocation and licensing in Saskatchewan. Participants suggest introducing a required annual licence fee for water users, part of which would go to the provincial government, Irrigation Crop Diversification Centre, Saskatchewan Irrigation Projects Association, and other producer groups. The portion of the fee going to the provincial government could be used to support enforcement of accurate water use reporting in the irrigation sector. Participants noted that currently there are accurate estimates of water use within Irrigation Districts, but accurate non-district water use information is not available.

3.3 IMPEMENTATION OF ALTERNATIVE WATER PRICING STRUCTURES

3.3.1 Potential Policy Intervention

The implementation of alternative water pricing structures for the Irrigation Agriculture Sector is applied to provide incentive to promote the optimization of water use (i.e., application of water to maximize productivity, providing a disincentive to overwatering, and minimize loss through the water delivery system). The overall policy objective is to increase the efficiency of the water delivery system and crop application to help achieve a 30% water loss reduction target (equivalently, a 30% reduction in water used to irrigate the given area of land). The intervention is initially focused on pricing to provide revenues to help pay for capital upgrades and maintenance of a more efficient water delivery system (i.e., rehabilitation of canals).

A rate is envisioned that is attached to Irrigation District fees. As a target, total revenues from fees should cover infrastructure life-cycle costs of the water delivery system, with the benchmark of all canals being lined in each Irrigation District. This policy intervention has the benefits of being technically straightforward to implement, with relatively low transaction and operating costs. The main disadvantage is that currently information on actual water use by individual irrigators is not accurately measured, and that fees do not vary by actual level of use, which would be required for the EI to be more effective and efficient in achieving WCEP objectives.

3.3.2 Results

Literature suggests that increases in irrigation water prices generally results in a reduction in use by up to a one-to-one ratio[4] (Savenije and van der Zaag 2002). As such, a 30 to 50% increase in water prices can potentially reduce consumption by the same amount without changing current irrigation infrastructure. The amount of water conserved with the price change is then available for other uses, and could be used to expand the current irrigation to cover a larger area without increasing total consumption.

The estimated change in revenue by increasing current water prices in three of Saskatchewan's Irrigation Districts (i.e., the SSRID, RID, and LLID) is shown in Table 3.3-1 to 3.3-3. The potential total additional revenue (Table 3.3-3) is the sum of the revenues from current water use (Table 3.3-1) and the increase in irrigation water use with water conservation that can occur without increasing total irrigation consumption (Table 3.3-2).

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[4] Savenije and van der Zaag (2002) reported a price elasticity of close to -1 for agricultural and industrial users when water fees increase.

Table 3.3-1. Estimated Revenue Change for Three Saskatchewan Irrigation Districts with Increased Water Fees

Irrigation District	Current Water Prices ($/acre-ft)[1]	Estimated Revenue from Current Water Fees ($/a)[2]	Water Price to Achieve 30% Use Reduction ($/acre-ft)[3]	Estimated Revenue with Water Increase in Water Fees ($/a)[2]
South Saskatchewan Irrigation District	$23.45/acre of land + $3.75/acre-ft. water used	$965,000	$30.49/acre + $4.88/acre-ft used	$1,254,000
Riverhurst Irrigation District	$60/acre-ft	$687,000	$78/acre-ft	$892,000
Luck Lake Irrigation District	$60/acre-ft	$609,000	$78/acre-ft	$792,000

[1] 2010 prices from SSRID.
[2] Calculated using the current irrigated acres from Table 3.1-1, an assumed water use of 1 acre-ft. for each irrigated acre, and rounded to the nearest $1000.
[3] Based on assumption of a one-to-one ratio between per unit price increases and per unit reduced water use reported by Savenije and van der Zaag (2002).

Table 3.3-2. Additional Revenue for Three Saskatchewan Irrigation Districts from Sale of all Conserved Water to Irrigators

Irrigation District	Current Water Prices ($/acre-ft)[1]	Water Price to Achieve 30% Use Reduction ($/acre-ft)[2]	Additional Irrigated Land (acres)[3]	Potential Additional Revenue ($/a)[4]
South Saskatchewan Irrigation District	$23.45/acre of land + $3.75/acre-ft water used	$30.49/acre + $4.88/acre-ft used	10,640	$376,000
Riverhurst Irrigation District	$60/acre-ft	$78/acre-ft	3,433	$268,000
Luck Lake Irrigation District	$60/acre-ft	$78/acre-ft	3,045	$238,000

[1] From SSRID (2012).
[2] Based on assumption of a one-to-one ratio between per unit price increases and per unit reduced water use reported by Savenije and van der Zaag (2002).
[3] Calculated as 30% of the current irrigated acres in in each district and assuming that one acre-ft. of water is used over all irrigated acres.
[4] Calculated using the increased price for water that achieved the 30% water use reduction and rounded to the nearest $1000.

Table 3.3-3. Additional Revenue from Water Price and Irrigated Acre Increases for Three Saskatchewan Irrigation Districts

Irrigation District	Additional Revenue from Price Increase ($/a)[1]
South Saskatchewan Irrigation District	$665,000
Riverhurst Irrigation District	$473,000
Luck Lake Irrigation District	$421,000

[1] Calculated by subtracting current revenue from revenue after 30% water fee increase and then adding revenue from increased irrigation acres for each district using information from Tables 3.3-1 and 3.3-2.

As proposed by this policy intervention, any change in pricing that would result in an increase in revenues (Table 3.3-3) would be associated with the concurrent rehabilitation of canals and/or conversion to irrigation piping. If the conserved water is used to irrigate 30% more land this has the potential to result in a net farm return of approximately $188/acre (estimated benefit of irrigating versus current dryland production; Clifton 2007). Thus, in order to arrive at a NPV estimate, the net farm benefits must be compared with the cost of infrastructure improvements. Specifically, the cost of canal rehabilitation/conversion for the SSRID was compared with the additional benefits of improved agricultural production. This calculation of an NPV was only carried forward for the SSRID due to a lack of available secondary data for the other Irrigation Districts.

Estimates of NPV of both canal rehabilitation and pipe conversion within the SSRID are shown separately in Table 3.3-4. The estimate assumes that farm benefits and infrastructure improvements are made incrementally and are evenly distributed over the 10-year study period. In all cases, the estimated NPV was negative, meaning costs of the infrastructure improvements are greater than the benefits to agriculture. The NPV is estimated to be less negative for pipe conversion. Additional fees revenues of the targeted 30% are grossly inadequate to pay for the improvements; thus, substantial government investment would be required.

Table 3.3-4. NPV of Infrastructure Improvements with Alternative Water Pricing for the SSRID

	Present Value ($)		
	2% Discount	**5% Discount**	**8% Discount**
Canal Rehabilitation Only			
Benefit	$29.0 million	$24.9 million	$21.6 million
Cost	$49.6 million	$42.7 million	$37.1 million
NPV	**-$20.6 million**	**-$17.8 million**	**-$15.5 million**
Pipe Conversion Only			
Benefit	$29.0 million	$24.9 million	$21.6 million
Cost	$37.2 million	$32.1 million	$27.8 million
NPV	**-$8.2 million**	**-$7.2 million**	**-$6.2 million**
Additional Fee Revenue	**$5.9 million**	**$5.1 million**	**$4.5 million**

3.3.3 Conclusions

The analysis considered the increased revenue gained by increasing water prices and irrigated acres for the SSRID by 30% to meet WCEP objectives. Findings show that the additional fee revenue, unless fees are raised substantially from current levels, is not sufficient to meet the cost of canal rehabilitation/conversion. Furthermore, the NPV is negative, indicating that the social investment (i.e., government funding of infrastructure improvements) is not desirable.

However, it must be emphasized that a number of potential benefits and costs were not included in the analysis because of the limited availability of information. As such, the NPV estimate is a partial analysis. The analysis did not include any potential external benefits of water efficiency gains and improved agricultural production as canal rehabilitation/conversion progresses. This could also include, for example, the increased availability of water for other uses. It is likely that if other benefits from water conservation are identified and included in the analysis that there would be a net benefit to canal rehabilitation/conversion, particularly with the identification of higher value uses of saved water.

As a matter of policy, the Government of Alberta funds irrigation infrastructure construction and maintenance using a cost sharing ratio whereby the government of Alberta pays 75% and the irrigation districts pay 25% (IWMSC 2002a). The ratio reportedly is believed to reflect the benefit provided by irrigation infrastructure to the province and to the districts (IWMSC 2002a). Applying the 75%/25% cost sharing ratio used in Alberta to development of Saskatchewan's irrigation infrastructure could reduce the estimated total cost of canal rehabilitation or conversion to pipes that would be borne directly by the Irrigation Districts. The rehabilitation/conversion would then further increase water savings that may be used to further expand irrigation acres as proposed by the SIPA (2012). However, in comparing revenues to costs with a 30% fee revenue increase, either fees would need to be increased or the government share of funding would need to be approximately 80 to 85% of total costs.

Conserved water can also be made available to other uses including maintain ecosystem health and ensure sustainable provision of ES. Ensuring water is available for ecosystems and ES provision should be considered when developing policy initiatives (De Groot 2002; AESRD 2003, 2008). For the analysis, it was assumed that the conserved water would be used to increase the amount of irrigated farmland by 30%. Again, there are other potential uses that are possible, some of which may represent higher value use. Alternative water use would need to be explored further to better define likely net economic benefits.

3.4 IMPLEMENTATION OF A WATER METERING AND REPORTING STRUCTURE

3.4.1 Potential Policy Intervention

The use of water for irrigation is currently not metered in Saskatchewan. It should be noted that although metering is not current practice, stakeholders support enforcement of accurate water use reporting in the Irrigation Agriculture Sector. Water use is estimated for Irrigation Districts, but non-district water use information is not available. Implementation of a comprehensive metering program would require a substantial stakeholder commitment and investment, and there currently is very little appetite among producers for water metering. Further, the quality of the water is such that it may be difficult to maintain meters and ensure that they are operational.

An approach that provides a proxy to metering is examined. Specifically, the assumed policy intervention is a program that provides estimates of actual amounts of water used by irrigators and charges a modified fee for the water used. Based on knowledge of the configuration and capacity of the water delivery system of each user, in conjunction with information on watering time, estimates of water use can be made.[5] Information on the configuration and capacity of water delivery systems would be initially developed by an on-site survey of irrigators, and the resulting database maintained and updated on a regular basis. Data on the total time that irrigation systems are operating would be self-reported by each user to his/her respective irrigation association.

The main disadvantage of this policy intervention is that it relies on self-reporting (envisioned to be periodically verified by a third party) and, thus, is open to dishonesty in reporting. It is believed that peer relationships among members of each irrigation association would provide a mechanism to control the extent of cheating. The main advantage of the policy intervention is that it provides data on water use by the irrigation sector to support the further informed development of WCEP policy measures and, most importantly, provides a price incentive for conservation tied to use. In the longer term, it is anticipated that this policy intervention would eventually move to actual use of meters and real-time monitoring of water use by the irrigation sector.

3.4.2 Results

The analysis of water metering (via proxy) compares the increased farm-level benefit from expanding irrigated acres versus the cost of the program over a 10-year period to achieve a 30% reduction in

[5] Total water use = delivery capacity (m^3/hr) x watering time (hr).

water use. Because the proxy measurement of actual water use, as proposed (Section 3.4.1), is believed to be most reliable where pivots are used, implementation of the program is analysed only with respect to those farms (e.g., farms that have other irrigation setups, such as flood irrigation, are not included in the calculations). In estimating the cost of the program, the following additional assumptions are made:

- Approximately 53% of Saskatchewan's irrigated acres use pivots;
- The average pivot system can water approximately 133 acres (AgSask n.d.), and thus , the estimated number of pivots to irrigate 119,000[6] acres is approximately 895;
- Initial (year 1) on-site verification of farm irrigation setups and pivot configurations, and creation of irrigation database requiring approximately two full-time equivalents (FTEs) with a total cost of about $360,000[7];
- Annual labour costs for data entry, analysis, and reporting requiring approximately 0.5 FTEs with a total cost of about $82,500 per year[8];
- Water savings from the program (measurement and reporting on irrigation water use) is 30%, similar to the experience of municipalities (FCM and NRC 2003); and
- All water savings goes to expanding irrigated acres.

The number of additional acres that can be irrigated with the water saved by the metering program is estimated to be 35,700[9]. Applying the net farm return of $188/acre of irrigating versus dryland production (Clifton 2007) yields a total estimated benefit of approximately $6.7 million annually. The comparison of costs and benefits of metering (via proxy) and using the water conserved for irrigation over the 10-year period is shown in Table 3.4-1.

Table 3.4-1. NPV of Water Metering Program Implementation

	Present Value ($)		
	2% Discount	**5% Discount**	**8% Discount**
Benefit	$32.1 million	$26.4 million	$21.9 million
Cost	$673,000	$586,000	$515,000
NPV	**$31.4 million**	**$25.8 million**	**$21.4 million**

[1] Cost based on initial year one program setup and annual data collection, analysis, and reporting as defined in report text.
[2] Benefit based on an estimated $6.7 Million annually to farms from the additional irrigated acres once the program is implemented.
[3] Present value calculations are portioned assuming that the 30% water savings is realized over a 10-year period (even distribution of conservation results) and the saved water is used for irrigation that same year.

As an alternative to the analysis, the case for the installation of meters, rather than relying on a program that uses proxy measurement, is examined. The actual installation of meters assumes that this is technically feasible on existing pivots with minimal maintenance requirements. The estimated general average cost of purchasing and installing a water meter for a pipe averaging eight inches in

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[6] This is estimated by the number of irrigated acres in Saskatchewan watered by pivots (AgSask 2012b).
[7] Assumes annual individual salary of $75,000, employee cost multiplier of 2.2 (including overhead), and $30,000 for expenses, most notably including computer systems and software and travel.
[8] Assumes annual individual salary of $75,000 and employee cost multiplier of 2.2.
[9] Calculated as 30% of the current irrigated acres under pivot irrigation in Saskatchewan.

diameter is approximately $500 per installation (Baum et al 2009). Due acknowledgement is given that a wide variance on the type and cost of available meters exists. The total cost of installing meters on all existing pivots is, therefore, about $447,000. The results for the alternative intervention of installing meters are shown in Table 3.4-2. The difference from the previous analysis (Table 3.4-1) is the discounted meter installation costs.

Table 3.4-2. NPV of Water Metering Program Implementation with Meters

	Present Value ($)		
	2% Discount	**5% Discount**	**8% Discount**
Benefit	$32.1 million	$26.4 million	$21.9 million
Cost	$1,075,000	$931,000	$815,000
NPV	**$31.0 million**	**$25.5 million**	**$21.1 million**

[1] Cost based on a total of $447,000 to install meters on all estimated pivots ($500/Meter X 895 Meters = $447,000), in addition to costs assumed in the previous case (Table 3.4-1).
[2] Benefit based on an estimated $6.7 Million annually to farms from the additional irrigated acres once all meters are installed.
[3]Present value calculations are portioned assuming that 10% of the meters are installed each year over 10 years, and the saved water is used for irrigation that same year.

The water metering policy intervention assumes that water meters are installed on a majority of farms currently relying on irrigation, and that the subsequent monitoring and reporting of water use results in reduced use and conservation. Specifically, the assumed policy intervention is a program that provides estimates of actual amounts of water used by irrigators and charges a modified fee for the water used, thus creating an incentive for WCEP.

3.4.3 Conclusions

The NPV associated with the water metering program is strongly positive, making a case for implementation within the Irrigation Agriculture Sector to achieve WCEP objectives. Water metering shows potential to increase water efficiency though the incentive for users to avoid extra costs of using excess water provided that a suitable water price structure and enforcement system is in place (PRI 2004).

The administration costs associated with the implementation and ongoing management of a water metering program can be expected to be relatively modest (Table 3.4-1), and thus should not be an impediment to program development. For example, the Government of Alberta has created an online water use reporting system for water license holders to submit data on their use monthly or annually depending on the requirements of the license (AESRD 2012). The majority of licenses do not have a mandatory reporting requirement and reporting is largely voluntary, although there are those promoting mandatory reporting for all water license holders (AESRD 2012). A similar reporting system and regulatory changes in Saskatchewan can increase the accuracy of reported water use for water management decision-making in a cost-effective manner.

However, in the above analysis the basis for the benefits is assumed to be the increase in farm returns when the portion of water conserved is used to irrigate agricultural land that is currently not irrigated. This means that this water is not available for other downstream uses—such as municipal or industrial water use, recreational use, or ES benefits, among others. These other potential uses may be of high relative value, but this was not explored within the scope of this study.

4. Municipal

4. Municipal

4.1 CURRENT SITUATION

Of the total of approximately 515 municipalities in Saskatchewan, approximately 180 or 35% are without residential water meters. This is for a total served population of approximately 32,300 individuals and 16,300 private dwellings (representing approximately 3.5% of the total number of private dwellings in the province). The majority of these municipalities are small, with only eight having a population of greater than 600 (Table 4.1-1) - most of these, with the exception of Pilot Butte and Carlyle, are in northern Saskatchewan.

Table 4.1-1. Saskatchewan Municipalities without Residential Water Meters and a Population Greater than 600 Individuals

Municipality	Population (2011)	Number of Private Dwellings (2011)
La Loche	2,611	700
La Ronge	2,304	960
Pilot Butte	1,848	624
Carlyle	1,441	596
Ile-a-la-Crosse	1,365	443
Buffalo Narrows	1,153	449
Air Ronge	1,043	367
Pinehouse	978	282

Total municipal water use in Saskatchewan is summarized in Table 4.1-2. There can be considerable variability in demand between years. The main driving force behind the variability is believed to be associated with differences in climate between years (e.g., rainfall).

Table 4.1-2. Municipal Water Use in Saskatchewan, 1996 to 2010

Municipal Population Range	Annual Water Use (million m^3)		
	Minimum	Maximum	Mean
Greater than 150,000	439	561	502
25,001 - 50,000	363	486	433
10,001 – 25,000	339	474	429
3,001 – 10,000	392	463	420
2,001 – 3,000	319	415	361
1,001 – 2,000	299	388	351
501 – 1,000	278	395	349
251 – 500	290	388	348
1 – 250	271	366	326

The average water use in Saskatchewan households is approximately 18 m^3 per month, or about 591 LPD[10] (EnvCan 2011b). Volume-based rates for water and sewer in Saskatchewan average around $40.30 per month when under 10 m^3 (under 329 LCD[11]) per month is used, $66.60 per month when using 10 to 25 m^3 (329 – 822 LPD), and $84.08 per month for using 26 to 35 m^3 (854 – 1150 LCD) (EnvCan 2011b). The marginal[12] (per m^3) water rate in Saskatchewan is $1.78/$m^3$ under 10 m^3, and $1.75/$m^3$ over 10 m^3 (EnvCan 2011b).

4.2 GUIDANCE FROM SECTOR STAKEHOLDER ENGAGEMENT

As with the Irrigation Agriculture Sector, previous research (Rescan 2012) engaged stakeholders in the Municipal Sector and the results of workshops with these stakeholders provided some guidance on potential policy interventions.

Incentive programming around water metering was one of the main opportunities arising from the workshop discussion with the municipal sector. More effective water metering could provide better water use information for water management, but also provide benchmarks and goals that can be used to advance WCEP. A water metering incentive program could help improve the capacity of municipalities to replace old, non-functional meters and purchase new meters.

There is a potential need for new pricing models that encourage conservation. New pricing models should be based on full-cost and user-pay principles and be reflective of water use intensity. Fairness and social equity in new systems will also need to be addressed.

4.3 ALTERNATIVE WATER PRICING STRUCTURES

4.3.1 Potential Policy Interventions

The implementation of alternative water pricing structures for the Municipal Sector is applied to residential use only, to the exclusion of any changes to commercial or industrial water uses or pricing changes. Specifically, it is assumed that residential block rates are applied that reflect three price categories based on estimated average water use needs:

1. Base water needs for an “efficient” house.
2. Additional needs for a “non-efficient” house, with moderate additional water use needs.
3. Additional needs for a “non-efficient” house with more extensive water use needs.

In setting the block rate structure, emphasis is placed on distributional equity – that is, ensuring low costs of base water needs, with cost subsidization of low water use by high water use. Ideally, pricing should be set such that total municipal revenues equal, at a minimum, financial life-cycles costs (capital and operating) of the service.

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[10] The value of 18m^3 per day is based on the demand on water systems divided by the weighted average population for a given province or territory (see EnvCan 2011b). Calculations are sensitive to choice of water system, volumes, and portions of the population considered within each water system.

[11] Total per capita use calculated by dividing the total water use by the weighted population (EnvCan, 2011b). The calculation of the LCD using the 18m^3 average is done by converting m^3 to litres, multiplying the monthly average use by 12, and then dividing by 365 days/yr to get the LCD value, or (18m^3 = 18,000L*12months)/365 = 591 LCD

[12] The marginal price refers to the cost to obtain the next unit of a good or service. In this case, the marginal water rate is the cost of obtaining an additional m^3 of water. The marginal price can change depending on demand and supply factors.

4.3.2 Results

Literature reveals that municipal water price increases do not provoke an elastic reduction in water use, particularly as use approaches basic needs such as drinking, cooking, laundry, and sanitation (Savenije and van der Zaag 2002). An increase in water price of 100% would achieve a possible 25 to 30% reduction in water use (Savenije and van der Zaag 2002).

For the analysis, an assumed revised rate structure ensures that lower cost water is available for basic use while placing higher use costs on consumption beyond basic needs. The water consumption categories and monthly fees considered are based on Environment Canada (2011a) amounts discussed in Section 4.1. The three block categories presented in Section 4.3.1 were defined for the analysis:

1. Base water use to meet basic needs is defined as up to 10 m^3 per month. No price increase is attached to this level of use to reflect fairness of access to water for basic needs.
2. Non-efficient house need is defined as between 10 m^3 and 25 m^3 of water use per month, representing above basic use. Current average household use in Saskatchewan of approximately 18m^3 per month falls within this category.
3. Non-efficient house needs, with more extensive water use, is defined as between 26 and 35 m^3 of water used per month.

No information is readily available on the distribution of water use among residential users – rather, only average use data is available. This prevents a more detailed analysis of the effects of water price changes on different users, including marginal effects on different segments of the population.

Presuming that the goal of 30% reduction in water use is achieved, or from an average of 18 m^3 to an average of 13 m^3 per household per month[13], then an estimated 100% increase in current average municipal water pricing is required. The price change would result in: 1) an increase in revenues to municipalities because of the increase in fees charged above basic need use (municipal water price elasticity is estimated to be approximately -0.3); and 2) a decrease in the total costs of providing water (mainly reduced water treatment costs) because of the reduced total water use. There would also be expected to be external benefits, outside of the municipal water system, associated with the conserved water being available for other uses.

The current average monthly water and sewer charge in Saskatchewan, associated with use of 18 m^3 per household, is approximately $54.28 (EnvCan 2011b) corresponding to a total annual cost of approximately $651 per household. The number of households in Saskatchewan as of 2006 is reported to be 387,140 (StatSask 2007); assuming approximately 85% of households are on municipal meters, the total municipal revenues for water and sewer use is approximately $214 million/a.

Assuming a 100% increase in rates, including both flat fee and volumetric price rate components, total revenues to municipalities because of the increase in fees charged above basic need use is estimated to be $360 million/a, or an increase of approximately $146 million/a.[14] (Table 4.3-1).

[13] Calculated by subtracting 30% (5.4 m^3) from the monthly average consumption of 18 m^3 (EnvCan 2011a).

[14] After a 100% rate increase, total charge for the first block rate increases to $80.60/month, and the marginal rate for consumption from 10m^3 to 13m^3 increases from an average of $1.75/$m^3$ per month to $3.50/$m^3$ per month, for a total average monthly fee of $91.10 at 13$m^3$ consumption level.

Table 4.3-1. Comparison of Water Current and Increased Rates with Revenues to Achieve 30% Reduction in Municipal Water Use

Current Average Monthly Water and Sewer Rates[1]	Current Average Volume Consumed	Current Revenue[2]	Average Monthly Rate Needed to Achieve 30% Reduction in Use[1,3]	Average Volume Consumed after Rate Increase[2,3]	Revenue after Rate Increase[2,3]
\$54.39	18 m^3	\$214 Million	\$91.10	13 m^3	\$360 Million

[1] Based on addition of the lowest block rate plus the marginal rate up to 18m^3 or 13 m^3 as applicable before and after rate increase
[2] Revenue calculations based on the assumption that 85% of the 387,140 households in Sask. are metered and use the same amount of water. No separation of households using different amounts of water is done due to lack of information.
[3] Literature indicates that a rate increase of 100% is required to obtain a 30% reduction in use for municipal users (Savenije and van der Zaag 2002)

As mentioned, reducing current water use for Saskatchewan households that are currently on water meters from an average of approximately 18m^3 to 13m^3 per household per month will result in water and sewer cost savings to municipalities. However, available information does not permit a reasonable estimation of these cost savings. The saved water could potentially supply the demand of additional households to accommodate population growth.

As noted, the water that is conserved is also available to be used elsewhere. The benefits of water conservation associated with its use outside of municipal water systems potentially include, but are not necessarily limited to:

- Irrigation agriculture water use;
- Commercial and industrial water use (e.g., potash mine development);
- Recreational water use; and
- Maintenance and enhancement of ES.

4.3.3 Conclusions

The analysis presented here provides a partial picture of revenue impacts and costs to municipalities with implementing a fee increase to achieve a 30% reduction on water use to meet WCEP objectives. A number of potential benefits to water conservation are not able to be estimated because of a lack of information.

The use of water pricing to provide an incentive for conservation can be effective even if water fees are increased by 100% or more. Many European countries have water rates much higher than Canada (CCA 2009; EnvCan 2012b). For example, the average water price in Germany is around 700% higher than the Canadian average, and Germans consume an average of about one third as much water daily (CCA 2009).

Water conservation is reported to be better achieved via educating water users and funding the replacement of old high consumption household water delivery and sanitation hardware with new higher efficiency hardware[15] (Savenije and van der Zaag 2002; EPA 2012). Revenue from water price

[15] In this study, household water delivery and sanitation hardware includes items such as toilets, faucets, shower heads that have been linked to leakage that increases water use (EPA 2012).

increases can be spent on funding rebate programs to replace hardware. Many provincial governments and municipalities in Canada currently offer rebates and water efficiency kits to assist with meeting conservation targets (SWA 2010; Tasa 2012). The majority of leakage occurs from older and improperly functioning toilets, taps, and showers. Savings of an estimated 30% in water consumption and cost is achievable via the use of high efficiency hardware (EPA 2012).

4.4 EFFECTIVENESS OF WATER METERING

4.4.1 Potential Policy Interventions

This intervention focuses on the installation of water meters in small and medium urban municipalities in Saskatchewan that currently do not have meters in order to allow for more effective metering and charging for residential water use based on the amount of water consumed. The main benefits of this intervention are that it increases the amount of water available for other uses, potentially reduces the water treatment and service costs to municipalities, and provides the water use information necessary to support the implementation of water management policy.

4.4.2 Results

The analysis calculates the cost of installing meters in all currently unmetered municipally-served households in Saskatchewan. It is expected that the installation of meters results in water conservation. Water savings have been shown to range from approximately 10 to 40% after installation of municipal meters due to the water users being faced with a unit price based on the amount of water used versus the pre-metering application of a flat fee by the municipality (FCM & NRC 2003; Richards et al. 2009).

The average cost of installing a residential water meter is estimated to be $150, depending on the municipality and model of meter selected (Mangelsen 2008). There are approximately 16,300 dwellings in Saskatchewan that are served by municipal water but that are not presently metered. The approximate cost of installing meters in all households that presently do not have meters is, therefore, approximately $2.45 million. Assuming that the meters are installed over a 10-year period yields a total present value cost of from approximately $1.6 million (8% discount rate), to $1.9 million (5% discount rate), to $2.2 million (2% discount rate).

As noted in Section 4.1, the average water use in Saskatchewan is approximately 18 m^3 per household per month (EnvCan 2011a). Assuming that water use declines 30% after installing meters (i.e., to an average of approximately 13m^3 per household per month), there is a savings of an estimated 1.1 million m^3 annually after all households receive meters. The saved water could potentially supply the demand of an additional 7,000 households, assuming they are also using 30% less water than the current provincial average.

For municipalities, the potential benefits to installing residential water meters are as described in Section 4.3. There are also benefits of the information on residential water use that would result from metering. For example, understanding household-level use enables municipalities to better manage infrastructure and supply. More broadly, the information is valuable to support the design and implementation of water management policy.

4.4.3 Conclusions

The findings of the analysis of municipal meter installation indicate clear benefits to municipalities. The benefits, however, are difficult to quantify but are, nonetheless, evident. The realized water conservation is sensitive to water pricing. Along with metering, water prices should be established that provide a conservation incentive, such as an increasing block rate as assumed for the analysis presented in Section 4.3. Decision-makers can use the information collected from meters as part of water management planning.

5. Summary

5. Summary

5.1 IRRIGATION AGRICULTURE SECTOR

The analysis of water price changes for the Irrigation Agriculture Sector considered the increased revenue gained by increasing water prices and irrigated acres for Saskatchewan's largest Irrigation District (the SSRID) by 30% to meet WCEP objectives. Findings show that the additional fee revenue is not sufficient to meet the cost of canal rehabilitation/conversion. Furthermore, the NPV is negative, indicating that the social investment (i.e., government funding of infrastructure improvements) is not desirable based on economic efficiency considerations.

However, it must be emphasized that a number of potential benefits and costs were not included in the analysis because of the limited availability of information. As such, the NPV estimate is a partial analysis. The analysis did not include any potential external benefits of water efficiency gains and improved agricultural production as canal rehabilitation/conversion progresses.

The NPV associated with water metering is strongly positive, making a case for the implementation of metering (at least through the use of proxy measures) within the Irrigation Agriculture Sector to achieve WCEP objectives. Water metering shows the potential to increase water efficiency though the incentive for users to avoid extra costs of using excess water provided that a suitable water price structure and enforcement system is in place (PRI 2004).

5.2 MUNICIPAL SECTOR

For the Municipal Sector, a water and sewer volumetric use price change is expected to result in: 1) an increase in revenues to municipalities because of the increase in fees charged above basic need use; and 2) a decrease in the total costs of providing water because of the reduced total water use. The analysis of water price increases was only able to provide a partial picture of revenue impacts and costs to municipalities with implementing a fee increase to achieve a 30% reduction on water use to meet WCEP objectives. A number of potential benefits to water conservation are not able to be estimated because of a lack of available information. The use of water pricing can provide an effective incentive for conservation. In addition, additional revenues are then available to provide households with water saving incentives (e.g., toilet replacement rebates).

The findings of the analysis of municipal meter installation indicate clear benefits to municipalities and for meeting WCEP objectives. The realized water conservation is sensitive to water pricing. Water prices should be established that provide a conservation incentive, such as an increasing block rate.

5.3 RECOMMENDED NEXT STEPS

This study provided a partial economic analysis of implementing water pricing and water metering to meet WECP objectives for the Irrigation Agriculture Sector and the Municipal Sector. The selection of criteria to determine benefits and costs was done based on available information. The policy interventions examined for this study were defined at a high level and are presented as hypothetical case studies. Development of policy option details will require additional work by the Government of Saskatchewan in consultation with sector stakeholders. Once policy options are defined, further CBA and cost-effectiveness studies are recommended to refine the numbers presented in this study and add to the available information for decision-makers.

The management of water resource through market-style mechanisms and EIs has been successfully applied in other jurisdictions including Chile, Australia and, more recently, Alberta (Bjornlund et al. 2007). Market mechanisms to transfer water between demand sectors are water management tools that the Province of Saskatchewan can potentially apply. Such an approach promotes the efficient use of water resources. Further study of the use of market mechanisms for Saskatchewan is recommended to better understand the approaches that would work best given the legislative, socio-economic, and political context.

Information on ES benefits of water is deficient. For example, additional research is required to better understand water to maintain ecosystem health and support important aquatic species in watercourses. These values are important to consider in policy decisions. Water pricing policies require information on ES benefits for full cost pricing to be effective, and water markets require the information to ensure that trading does not undervalue ES benefits.

References

References

Allender, Hans D. 2012. “Determining the Economical Optimum Life of Residential Water Meters”. http://www.wwdmag.com/meters/determining-economical-optimum-life-residential-water-meters (accessed August 17, 2012).

Alberta Environment and Sustainable Resource Development (AESRD). 2012. *Water Use Reporting*. http://www.waterforlife.alberta.ca/02642.html (accessed August 28, 2012).

Alberta Environment and Sustainable Resource Development (AESRD). 2008. *Water for Life: A Renewal*. Edmonton AB.

Alberta Environment and Sustainable Resource Development (AESRD). 2003. *Water for Life: Alberta’s Strategy for Sustainability*. Edmonton Alberta.

Alberta Agriculture and Rural Development (AARD). 2012. *Alberta Irrigation information. Facts and Figures for the Year 2011*. Basin Water Management Branch. Irrigation and Farm Water Division. Lethbridge AB. http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/irr7401/$FILE/altairriginfo2011.pdf (accessed August 14, 2012).

Baum, Melissa C., Dukes, Michael D., and Haman, Dorota Z. 2009. *Selection and Use of Water Meters for Irrigation Water Measurement*. University of Florida. IFAS Extension. http://edis.ifas.ufl.edu/ae106 (Accessed August 9, 2012).

Bohanna, David. 1998. “Water Meters: An Incentive to Conserve and a Signal to the Market”. *Economic Affairs*. 18(2): 10 – 13.

Bjornlund, Henning., Nicol, Lorraine., and Klien, Kurt K. “Challenges in Implementing Economic Instruments to Manage Irrigation Water on Farms in Southern Alberta.” *Agricultural Water Management*. 92: 131-141.

Brandes, Oliver M., Rensetti, Steven., and Stinchcombe, Kirk. 2010. *Worth every Penny: A Primer on Conservation Orientated Water Pricing*. POLIS Project on Ecological Governance. University of Victoria. Victoria BC.

Burt,Charles M. 2008. “Canal Seepage Reduction by Soil Compaction”. Presented to the IA Technical Conference. Anaheim CA. Nov. 2008.

Cantin, Bernard.,Shrubsole, Dan., and Aït-Ouyahia, Merium. 2005. “Using Economic Instruments’ for Water Demand Management”. *Canadian Water Resources Journal*. 30: 1-10.

Clifton Associates (Clifton). 2008a. *A time to Irrigate: The Economic, Social, and Environmental Benefits of Expanding Irrigation in he Lake Diefenbaker Region. Volume 1*. Prepared for the Saskatchewan Irrigation Projects Association. Regina SK.

Clifton Associates (Clifton). 2008b. *A Time to Irrigate: The Economic, Social, and Environmental Benefits of Expanding Irrigation in he Lake Diefenbaker Region. Volume 2*. Prepared for the Saskatchewan Irrigation Projects Association. Regina SK.

Columbia Basin Trust (CBT). 2012. *Frequently Asked Questions about Water Meters*. http://www.cbt.org/uploads/pdf/WaterMeterFAQ_final.pdf (accessed August 13, 2012).

Council of Canadian Academics (CCA). 2009. *Sustainable Management of Groundwater in Canada. Report of the Expert Panel on Groundwater*. Ottawa ON. http://www.scienceadvice.ca/uploads/eng/assessments%20and%20publications%20and%20news%20releases/groundwater/(2009-05-11)%20gw%20report.pdf (accessed August 28, 2012).

De Groot, R.S., Alkemade, R., Braat, L., Hein, L., and Willemen, L. 2009. "Challenges in Integrating the Concept of Ecosystem Services and Values in Landscape Planning, Management, and Decision Making". *Ecological Complexity*. 7(3): 260-272.

Environment Canada (EnvCan). 2012. *Water-How We Use It*. https://www.ec.gc.ca/eau-water/default.asp?lang=En&n=0BBD794B-1#a10 (accessed August 10, 2012).

Environment Canada (EnvCan). 2011a. *2011 Municipal Water Use Report: Municipal Water Use, 2009 Statistics*. http://www.ec.gc.ca/Publications/B77CE4D0-80D4-4FEB-AFFA-0201BE6FB37B/2011-Municipal-Water-Use-Report-2009-Stats_Eng.pdf (accessed August 17, 2012).

Environment Canada (EnvCan). 2011b. *Municipal Water and Wastewater Survey Municipal Water Pricing: 2009 Summary Tables*. http://www.ec.gc.ca/eau-water/ED0E12D7-1C3B-4658-8833-347B527C688A/MWWSWaterPricingSmmaryTables2009_EN.pdf (accessed August 17, 2012)

Government of Saskatchewan (GovSask). 2012. *Average Water and Sewer Costs for Saskatchewan Communities as of May 31, 2012*. http://www.municipal.gov.sk.ca/MID/Transportation-Utilities/WaterSewerCostsPDF (accessed August 10, 2012)

Hill, Robert W. 2000. *How Well Does your Irrigation Canal Hold Water? Does it Need Lining?* All Historical Publications. Paper 148. University of Utah. http://digitalcommons.usu.edu/extension_histall/148 (accessed August 14, 2012

Iqbal, Z., MacLean, R.T., Taylor, B.D., Hecker, F.J, and Bennett, D.R. 2002. "Seepage Losses from Irrigation Districts in Southern Alberta". *Canadian Biosystems Engineering*. 44: 1.21 – 1.27.

Irrigation Water Management Study Committee (IWMSC). 2002a. *South Saskatchewan River Basin: Irrigation in the 21st Century. Volume 1: Summary Report*. Alberta Irrigation Projects Association. Lethbridge, Alberta.

Irrigation Water Management Study Committee (IWMSC). 2002b. *South Saskatchewan River Basin: Irrigation in the 21st Century. Volume 5: Economic Opportunities and Impacts*. Alberta Irrigation Projects Association. Lethbridge, Alberta.

Justice Canada. 2012. *Figure 2.4 Average Number of Persons per Household By Province or Territory (1996*). http://justice.gc.ca/eng/pi/rs/rep-rap/2003/rr03_la14-rr03_aj14/fig24.html (accessed August 29, 2012).

McNiell, Roger and Tate, Donald. 1991. *Guidelines for Municipal Water Pricing*. Environment Canada Social Science Series No. 25. Inland Waters Directorate. Water Planning and Management Branch. Ottawa ON.

Mangelsen, Melissa. 2008. "Water Meters Upgraded". *Nipawin Journal*. http://www.nipawinjournal.com/ArticleDisplay.aspx?e=2024705&archive=true

Millennium Ecosystem Assessment (MA). 2005. *Ecosystems and Human Well-Being: Synthesis*. World Resources Institute. Island Press. Washington DC.

Federation of Canadian Municipalities (FCM) and National Research Council of Canada (NRC). 2003. *Establishing a Metring Plan to Account for Water Use and Loss.* http://www.fcm.ca/Documents/reports/Infraguide/Establishing_a_Metering_Plan_to_Account_for_Water_Use_and_Loss_EN.pdf (accessed August 17, 2012).

Percy, David R. (1996). “Seventy-Five Years of Alberta Water Law: Maturity, Demise, and Rebirth”. *Alberta Law Review*. 35(1): 221-241.

Portney, P.R. and Weyant, J.P., eds. 1999. *Discounting and Intergenerational Equity*. Washington, DC: Resources for the Future.

Policy Research Initiative (PRI), 2005. *Economic Instruments for Water Demand Management in an Integrated Water Resources Management Framework. Synthesis Report*. Ottawa, Ontario

Rescan. 2012. *Prairies Regional Adaptation Collaborative. Water Conservation, Efficiency, and Productivity in Saskatchewan.* Prepared for Saskatchewan Watershed Authority by Rescan Environmental Services Ltd. Saskatoon SK.

Richards, Gregory L., Johnson, Michael C., and Barfuss, Steven L. 2009. “Metering residential irrigation water: Technological approaches and cost estimations” *American Water Works Association Journal*. 101(6): 52 – 63.

Saskatchewan Bureau of Statistics (StatSask). 2007. *Saskatchewan Families and Households.* http://www.stats.gov.sk.ca/stats/pop/2006CensusFamiliesandHouseholds.pdf (accessed August 27, 2012).

Saskatchewan Irrigation Projects Association (SIPA). 2008. *A Time to Irrigate: Benefits of Irrigation Investment in Saskatchewan.* http://www.irrigationsaskatchewan.com/SIPA/content/STK-Saskatchewan.pdf (Accessed August 10, 2012).

Saskatchewan Ministry of Agriculture (AgSask). 2012a. *Rehabilitating the M1 Canal.* http://www.agriculture.gov.sk.ca/agv1202_pg10 (accessed August 15, 2012).

Saskatchewan Ministry of Agriculture (AgSask). 2012b. *Intensive Irrigation in Saskatchewan. Exploring the Potential.* Presented at the 99th Saskatchewan Stock Growers Association 2012 Annual General Meeting. Cypress Hills Provincial Park. Cypress Hills SK. May 27-29, 2012. http://skstockgrowers.com/wp-content/AGM%202012/Gerry.pdf (accessed August 29, 2012).

Saskatchewan Ministry of Agriculture (AgSask). 2003. *Irrigation in Saskatchewan.* http://agriculture.gov.sk.ca/Default.aspx?DN=59abfaba-401e-49fb-91d0-d357692288d4 (accessed August 17, 2012).

Saskatchewan Ministry of Agriculture (AgSask). n.d. *The Centre Pivot Irrigation System.* http://www.agriculture.gov.sk.ca/Default.aspx?DN=b84a9a68-9ad9-43a1-8f09-c41f1fb9fa6e (accessed August 17, 2012).

Saskatchewan Watershed Authority (SWA). 2010. *Water Use in your Home: What you Need to Know to Use Less and Spend Less.* http://www.swa.ca/Publications/Documents/ConservationBooklet_2010.pdf (accessed August 27, 2012).

Savenije, Hubert H.G. and van der Zaag, Pieter. 2002. “Water as an Economic Good and Management Paradigms with Pitfalls.” *Water International*. 27(1): 98 – 104.

Tasa, Devan C. 2012. “Water Conservation a Priority for Camrose”. *The Camrose Canadian.* http://www.camrosecanadian.com/ArticleDisplay.aspx?e=3601770 (accessed August 27, 2012).

Tietenberg, Thomas. 2006. *Environmental and Natural Resource Economics*. 7th Ed. Pearson Education Inc. Boston MA.

Treasury Board of Canada. 2007. *Canadian Cost-Benefit Guide: regulatory Proposals*. Treasury Board of Canada Secretariat: Ottawa, ON.

United States Environmental Protection Agency (EPA). 2012. *Every Drop Counts*. http://www.epa.gov/watersense/pubs/every.html (accessed August 27, 2012).

Western Irrigation District (WID). 2012. *Western Irrigation District 2011 Annual Report*. http://www.wid.net/adobe/wid2011_annualreport.pdf (accessed August 14, 2012).

Young, Robert A. 2005. *Determining the Economic Value of Water: Concepts and Methods*. Resources for the Future. Washington DC. USA.