Ecosystem Services Approach Pilot on Wetlands

Economic Valuation Technical Report

FINAL REPORT
October 2011

Government

ISBN Number 978-1-4601-0288-6 (Printed Version)
ISBN Number 978-1-4601-0289-3 (Online Version)
Web Site: http/www.environment.alberta.ca

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Special thanks to all Socio-econ Sub-team members and Justin Wilkes for providing GIS assistance. Thanks to the City of Calgary for providing assessment data for the aesthetic/amenity valuation analysis and for assisting in data collection of the travel cost survey. Thanks to Peter Boxall (University of Alberta) for providing early insights on the recreation assessment component and Jared Prins (Alberta Tourism, Parks and Recreation) for reviewing the survey.

Thanks to Ciara Raudsepp-Hearne, Geneva Claesson, Courtney Hughes, Brett Johnson, Gillian Kerr, Glenn Brown, Paul Adamus, Eric Beveridge, Rob Simieritsch and Karen Raven for various contributions to this report.

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About This Report

The Ecosystem Services (ES) program within Alberta Environment and Sustainable Resource Development (ESRD) has been advancing the use of an ES Approach within the department since 2007. The Ecosystem Services Approach Pilot on Wetlands (the ES Pilot) is part of the Department's 10-year ES Roadmap; its completion and results are considered a progression in understanding and applying an ES Approach to support decision making.

The Socio-economic Sub-team is one of the sub-teams in the Pilot tasked to conduct economic valuations of wetland ES in the study area. This technical report was prepared for the ES Pilot team members, technical professionals, and other target groups/individuals with interests in economic valuation. This valuation research also served to build knowledge and capacity in economic analysis techniques within the department. This report documents the approaches undertaken by the Socio-econ Sub-team to conduct economic valuations and deliver major deliverables and to discuss the links of economic valuation to wetland decision making. Limitations, caveats and next steps are also discussed.

Readers should note that the complexity of ecosystems and interactions with people, including the functions, services and benefits they provide, is a challenging new arena for science. The work of the Socio-econ Sub-team and the results presented is a step forward in building and understanding about ecosystem services and their values; however the team understands that further research and application is needed to refine both the process and the assessments. Therefore, there are limitations in the information presented. The results need to be considered advancements in ES knowledge in Alberta, but considered 'pilot results' with caveats. Based upon advice and experience of international experts it is understood that the work to assess ES within a strong policy context, and using knowledge from multiple disciplines, is leading edge, and attempts were made to ensure the results presented are credible, legitimate and policy relevant.

Executive Summary

The Ecosystem Services Approach Pilot on Wetlands (the ES Pilot) is part of Alberta Environment and Sustainable Resource Development's 10-year ES Roadmap; the Pilot's completion and results are considered a progression in understanding and applying an ES Approach to support decision making. This economic valuation technical report is one of the technical reports developed for the Pilot and forms the basis for providing monetary estimates of benefits from wetlands in the Shepard Slough study area. This valuation is part of the Ecosystem Services Approach adapted from the Millennium Ecosystem Services Approach.

Shepard Slough ('the study area') covers approximately 274 km^2, encompassing part of the City of Calgary, Rocky View County and the Town of Chestermere. The study area is primarily agriculture (~57%), with increasing settled areas (~17%) and industrial areas (~10%). About 11%, or 24.5 km^2 (or 2,450 hectares), of the landscape is covered by wetlands. This area has been facing land use changes often leading to loss or alteration of wetlands over the past several decades. These land use changes has meant that ecosystem services provided by wetlands have either been lost or altered. In the context of decision making this loss and alteration has not been well understood or accounted for. Wetland regulatory decision makers identified three major gaps with respect to current decision making process. Economic valuation, using the total economic value framework, was used to help address these three major gaps identified by the wetland approval decision makers.

There is limited ability to communicate the 'values' of wetlands

Economic valuation showed that wetlands contribute to human well being by providing services that would otherwise need human intervention and infrastructure expenditure. For example, the economic values of wetland regulating services (such as flood control, water purification and carbon storage) are large and can be more effective and less costly than engineering solutions. The aesthetic benefit, expressed through premium paid for houses located nearby a wetland and recreation opportunities provided by wetlands are significant. These results can be a powerful tool to communicate the values of wetlands with different stakeholders involved in wetland management process.

There is insufficient consideration of cumulative effects and long-term consequences of decision making

The distribution of economic value and annual value loss on a landscape map can provide useful information in high-level strategic planning with the consideration of cumulative effects. For example, flood control benefit wetlands between 0.1 and 1.0 ha account for over eight per cent of the total, which, although small, is almost as high as the total of those wetlands between 5 to 10 hectares. In addition to the spatial dimension, there is enough flexibility for different development scenarios to be applied and to show the corresponding consequences of different development paces. We used historic wetland loss rate and also projected future potential loss. This projection could be modified using more sophisticated scenario planning. This exercise would be helpful for decision makers when undertaking planning exercise to try and understand the cumulative impact of wetland loss.

There is insufficient evidence to support avoidance, minimization and compensation decisions on wetlands

Economic valuation of wetlands across the landscape can help identify heterogeneous value areas and thus identify priorities for wetland management decisions. From a management perspective wetlands of higher values could be linked to avoidance decisions compared to lower value which might support minimization or compensation decisions. Thus economic valuation of wetland within the ES framework can provide evidence to support the management hierarchy of wetland approval process and also wetland management planning at larger landscape scales.

Results of the valuation are summarized in Table EX1. It should be noted that although monetary values of benefits have been calculated, it is not appropriate to aggregate these values across the services. It is partially because of the different scales being used for valuation and value measures (e.g. total, average, marginal value) also differed amongst the ES. Some other limitations and caveats remain. There is still incomplete understanding of changes in ES and how that relates to human wellbeing. Economic valuation provides a 'snapshot' of complex and dynamic system and potentially ignores the complex interdependencies among ES. Valuation also assumes that there are no thresholds, discontinuities, or irreversibility in ecosystem functions. In reality, ecosystems have thresholds and services that are likely interdependent.

Data and resource constraints influenced the application of valuation methods and in some cases a 'second best' valuation method was used. Although reasonable care was taken when using benefit transfer, further work to refine and calibrate those values to local context is recommended. A project of this size and scope involves multiple teams and disciplines, with the interdependencies among their work. Better coordination and integration among work tasks as well as awareness of the dependencies on biophysical assessment outputs to conduct economic valuation is needed. In spite of these limitations and caveats, we believe that valuation provides useful information and can assist in making more informed wetland management decisions.

Important to note that this valuation study does not capture all potential benefits associated with wetlands. While we have attempted to be comprehensive in our analysis, only a suite of most relevant ES in the study area was assessed. With the analysis to continue focusing on locally relevant ES to assist in the decision making, a broader suite of ES categories could be assessed to gain a holistic picture of all wetland ES and benefits in future studies. It is also acknowledged that ecosystems are considered to have intrinsic value, independent of the services they provide to humans. However, it is beyond the scope of this study to assess this type of value.

Table EX 1 Valuation Summary of Ecosystem Services Examined

Ecosystem Service	Valuation Method(s)	Value Measure(s)	Valuation Scale(s)
Flood control	Wetland restoration costs	• Average value: $17,500/ha • Total value: $43 million	• The study area • Sub-watershed
	Replacement costs of constructed wetlands	• Average value: $252,000/ha • Total value: $338 million	
	Flood risk evaluation	• No monetary value was derived	
Water purification	Wetland restoration costs	• Average value: $17,500/ha • Total value: $43 million	• The study area • Sub-watershed
	Replacement costs of constructed treatment wetlands	• Average value: $28,908-$141,649/ha/year • Total value: $71 million-$347 million/year	
	Replacement costs of conventional treatment facilities	• Total value: $141.6 million- 694.1 million /year	
Carbon storage	Varied value measures of carbon	• Average value: ▪ $2-$982 carbon/tonne ▪ $15/tonne of $CO2_{eq}$ (Alberta-based) • Total value: ▪ $0.6 million-$299 million ▪ $16.7 million (Alberta-based)	• The study area
Recreation	Travel cost method	• Total value: $4.4 million/year	• Site-specific (RKP)
Aesthetic /amenity value	Hedonic pricing method	• Marginal value: ▪ Loss of $27 in house value if one additional meter away from a wetland ▪ Increase of $4,391- $5,136 in house value if adjacent to a wetland • Total value: ▪ $16.7 million for value of proximity ▪ $0.3 million -$0.8 million for value of adjacency	• Residential community based
Water supply	Consumption of water by livestock	No monetary value was derived	• The study area
Educational /scientific opportunities	School visitations; travel distance	No monetary value was derived	• Site-specific (RKP)
Pollination	Benefit transfer	No monetary value was derived specific to the study area	• National wide

1 Introduction

This report is prepared for the Ecosystem Services (ES) Approach Pilot on Wetlands project team members, technical professionals, and other target groups/individuals with special interests in technical details and also from a capacity building perspective. It seeks to:

- Document the approaches undertaken by the Socio-econ Sub-team within the Pilot to conduct economic valuations and deliver major deliverables;
- Identify the information and capacity gaps in valuation implementation;
- Discuss the sub-team's lessons learned and limitations in the application; and
- Be a source document for team members and external experts to ensure a shared understanding of the economic valuation in the ES Pilot.

The analysis draws on different data sources (e.g., biophysical assessments, government databases, contractors' work, etc.), as well as from existing studies and scientific literature. The report is organized into nine sections:

Section 1 introduces the ES Pilot project and provides a brief overview of the case study area, wetland ES and why economic valuation is crucial in our context.

Section 2 discusses the concepts of value and valuation and how the economic valuation framework and the ES framework can be used in a complementary fashion.

Section 3 identifies different types of value measures and reviews economic valuation techniques commonly used in valuing ES.

Section 4 considers a set of criteria to evaluate the suitability of particular valuation methods for specific ES.

Section 5 focuses on economic valuations for the selected ES. It describes the methods chosen, data collection and discussion of results for the selected ES.

Section 6 provides the conceptual outline of the land value mapping approach in ES valuation. It explores the use of a wetland rapid field assessment approach as the basis for economic valuation of ES.

Section 7 summarizes the results of economic valuation practices and the economic methods applied along with data sources and limitations.

Section 8 discusses the contributions of economic valuation into wetland approval process and in particular the linkages to addressing the major gaps identified by wetland approval decision makers.

Section 9 concludes with some limitations and caveats.

1.1 Overview of the Ecosystem Services Approach Pilot

Ecosystem services ('ES') are the benefits that nature provides to people. Ecosystem services are valuable, as they provide 'free' inputs into development objectives and to realizing quality of life goals. For example, the flood control service of wetlands can help to protect homes, infrastructure and communities during extreme weather events.

The Ecosystem Services Approach Pilot on Wetlands ('the ES Pilot') was initiated in 2010 as one of the short-term goals of Alberta Environment and Sustainable Resource Development's *Road Map for Ecosystem Services in Alberta*. The Road Map articulates a strategy for integrating ES into Alberta Environment and Sustainable Resource Development's (ESRD) governance, policy and programs. The ES Pilot contributed to the short-term goals of enhanced appreciation and understanding of ES in policy, planning and decision making. The ES Pilot focused on assessing the benefits that people acquire from wetlands in a qualitative, quantifiable and comparable way. The ES Pilot was conducted in an area encompassing the east part of the City of Calgary, Rocky View County and the Town of Chestermere, where residential sub-division developments are having an impact on the ES provided by the landscape.

The scope of the ES Pilot was determined in the fall of 2010 through discussions with wetland experts, regional government staff, and biological/ecological/economic experts from ESRD, other ministries and other institutions. The outcome for the pilot was established as "the development and operationalization of an ES Approach to provide a tool to enhance decision making". The pilot charter originally had five objectives but these were modified and evolved to three overarching objectives to guide the ES Pilot:

- Test and demonstrate how an ES Approach can be used to support decision making by explicitly demonstrating the tradeoffs between development and ES benefits provided by wetlands;
- Support wetland management in the province by providing additional information to support potential compensation decisions related to land-use development; and
- Identify information and capacity gaps for ES assessment to support future ES work.

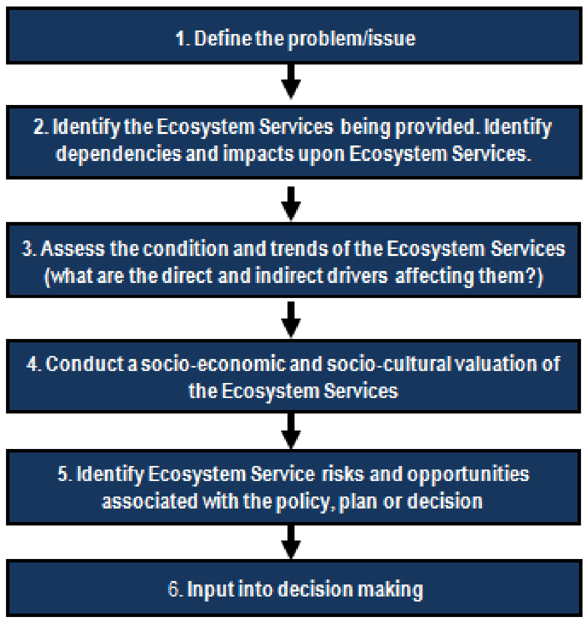
Currently, the full array of wetland benefits is not well understood. Thus decisions regarding wetlands are made without complete understanding of individual and cumulative ES benefits that are being improved, degraded or lost. Wetland approval decision-makers in the ES Pilot identified several critical gaps in the current wetlands approval process. The ES Pilot was designed to help address the three prioritized gaps in Text Box 1.

Text Box1 - Three Prioritized Gaps in the Current Wetland Approval Process:

- There is insufficient evidence to support avoidance, minimization and compensation decisions on wetlands.
- There is insufficient consideration of cumulative effects and long-term consequences of decision-making.
- There is limited ability to communicate the 'values' of wetlands.

In particular, the first key objective was to test and demonstrate how to operationalize an ES Approach for Alberta based on existing research and available methods from other organizations and jurisdictions. The ES Approach developed for the Alberta context (Figure 1.1) provides a framework to help identify and quantify the benefits provided by wetland ecosystems, with the goal of improving decision-making. As improvements are made in describing and valuing the benefits of ES, decision makers can better understand how their decisions might change (positively or negatively) the condition, quality and/or quantity of ES that could have an impact on the well-being and quality of life of Albertans, and the businesses that operate in the province.

Figure 1.1 The ES Pilot – ES Approach



Meeting these objectives involved developing biophysical, socio-cultural and economic information on wetland ES to address gaps identified by wetland approval decision-makers. A Socio-econ Sub-team was formed as a multi-disciplinary team, composed of economists, ecologists, sociologists and other professionals. Along with helping develop the ES Approach in the Alberta context, the Sub-team was mainly tasked to conduct an economic valuation of the ES derived from wetlands in the case study area, which is one component of Step 4 in the ES approach (see *The Socio-econ Sub-team Terms of Reference*). One of the sub-team's responsibilities was to explore the key methodologies that can be used to deliver on the major deliverables. The sub-team also worked collaboratively with other sub-teams to ensure the integration and acknowledgement of different perspectives where appropriate. A fundamental premise underpinning the ES Approach is to highlight the connection between the natural environment and human well being. This part of the project focused on assessing the changes in human well being due to changes in the natural environment. However, we acknowledge that some components of well being are not amenable to estimation through economic valuation techniques, these components were assessed in the socio-cultural assessment practice of wetland ES (see the *'Socio-cultural Technical Report'*).

1.2 Case Study Area

The case study area ('the Study Area') chosen by the ES Pilot covers approximately 274 km^2, encompassing part of the City of Calgary, Rocky View County and the Town of Chestermere (Figure 1.2). This area was chosen for the ES Pilot because of the large number of wetlands in the area, current pressure from residential sub-division development and the existence of data to support spatial analysis of ES. The study area is primarily agriculture (~57%), with increasing settled areas (~17%) and industrial areas (~10%). About 11 per cent, or 24.5 km^2 (or 2,450 hectares), of the landscape is covered by wetlands.

There are over 6,600 wetlands in the study area, ranging in size from less than 0.1 hectare to over 10 hectares. The largest wetlands are found in the Shepard Slough Complex, located in the southern end of the study area. Due to its geographic position, this catchment area has been facing land use changes. One such pressure is suburban developments that often lead to loss or alteration of wetlands. Wetland coverage has changed greatly in the past several decades, with 75 per cent of the wetlands that existed in the study area in 1962 remaining today (Badiou, 2011a). This translates into a total loss of 7.7 km^2 of wetlands during this period. However, it should also be recognized that wetland loss in the area since settlement is likely much higher.

This area is nested within the South Saskatchewan Region. Historic landscape change has been significant in the South Saskatchewan Region, largely driven by population growth and agricultural expansion (SSRP Profile, 2009). Over a million hectares of prairie-parkland wetlands were drained and converted to agricultural use in the past century. Between 1970 and 1990, approximately 2.4 wetland basins per square kilometer were lost, primarily to agricultural use.

More recently, urban expansion has led to new changes on the landscape, including greater a percentage of impervious surfaces, stormwater pond creation and new micro-climactic conditions. Population and economic growth, particularly in the Calgary area, has led to expanded development in the South Saskatchewan Region. Its population has grown rapidly over the past decade, by approximately 20,000 persons per year on average. Rural and agricultural lands are increasingly under pressure from rural residential development, while tracts of agricultural land have been converted to facilitate the geographic expansion of Calgary. The conversion of native landscapes over time has affected biodiversity in the region; it is now home to the largest number of species at risk in Alberta (SSRP Profile, 2009).

This economic and population growth has extended eastward into Rocky View County. The majority of Rocky View County's population growth has derived from net in-migration to the municipality rather than natural growth, and more than two-thirds of Rocky View's adults are employed outside of the municipality. The County's population over the period 1971 to 2006 grew from 10,400 to almost 34,200, an annualized growth rate of 3.5 per cent.

Accompanied with population growth is the increased pressure for residential development. The fastest growing residential development type in the South Saskatchewan Region is rural residential development. Given its low dwelling density, this type of residential development also exerts a large footprint on the land base. Rural residential development occurs predominantly along the Highway 2 corridor and around urban centers. Between 2000 and 2006, 87 per cent of the municipality's population increase occurred outside of the designated hamlets, and within acreage subdivisions. The most growth occurred between 1980 and 2002, especially around the margins of Calgary, in areas including Rocky View County (SSRP Profile, 2009). Incomes and residential property values in Rocky View are relatively high (Lovatt Planning Consultants Inc., 2008).

The trend of urbanization in the South Saskatchewan Region shows no signs of abating, as Alberta's economy continues to attract new residents from other parts of Canada and internationally. Consequently, urban areas may be under pressure to further expand in order to accommodate larger populations and associated residential and commercial development.

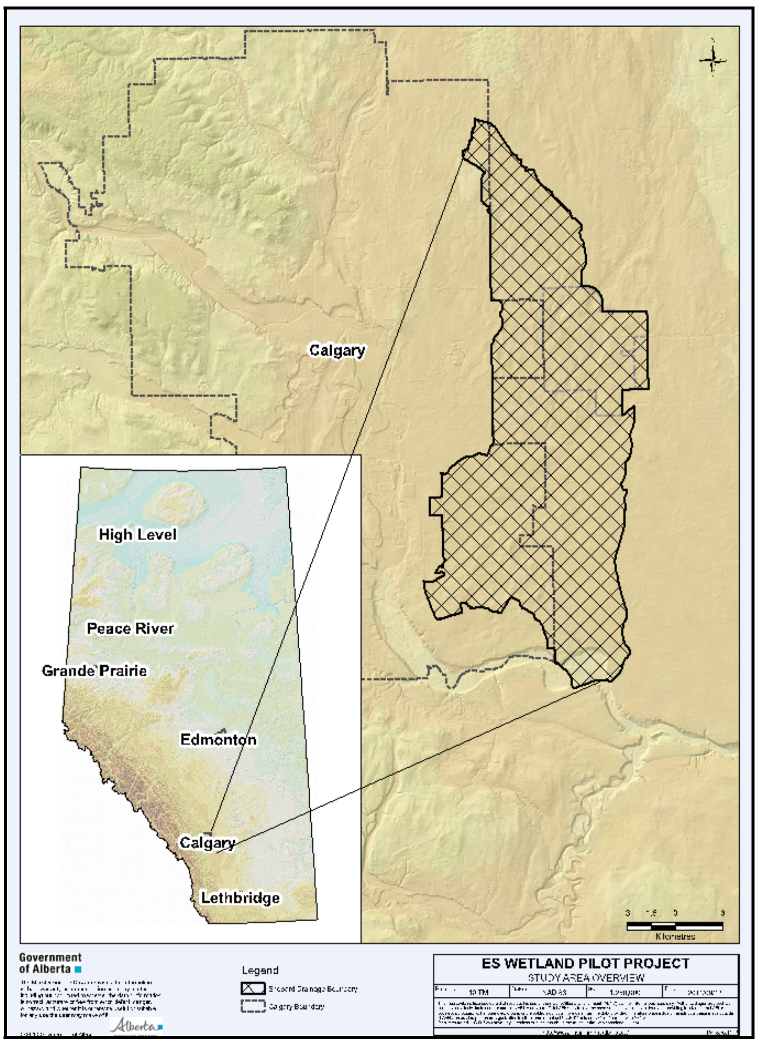


Figure 1.2 Case Study Area - Wetland Ecosystems in Rocky View County and East Calgary

1.3 Wetland Ecosystem Services in Case Study Area

Ecological Functions refer to natural processes that are necessary for the self-maintenance of an ecosystem and its integrity, such as primary production, nutrient cycling, decomposition, etc. *Ecosystem Services* represent goods and services derived from ecosystems that benefit people (see *Section 11 Glossary of Key Terms*). These are grouped into four major categories which are provisioning, regulating, cultural, and supporting services. It is synonymous with *'Ecosystem Goods and Services'* used in some other literature. In addition, *Benefits* are defined as positive changes in human wellbeing from the delivery of ecosystem services. Ecosystems, and the biodiversity contained within them, provide a stream of ES essential for society's well-being. The Pilot team has developed a master ES Cascade diagram and several ES specific diagrams to help understand the relationship and linkages between Natural Assets, Ecological Functions, Ecosystem Services and Benefits, along with possible measures of units for each category. Figure 1.3 is the Master ES Cascade Diagram which shows a simplified model of how ecosystems contribute to human wellbeing. The model outlines the flow of services and benefits from nature to people, and the four components of the flow sequence that are being used for the Ecosystem Services Approach Pilot on Wetlands. ES-specific Cascade diagrams are further presented in valuation sections for the selected ES.

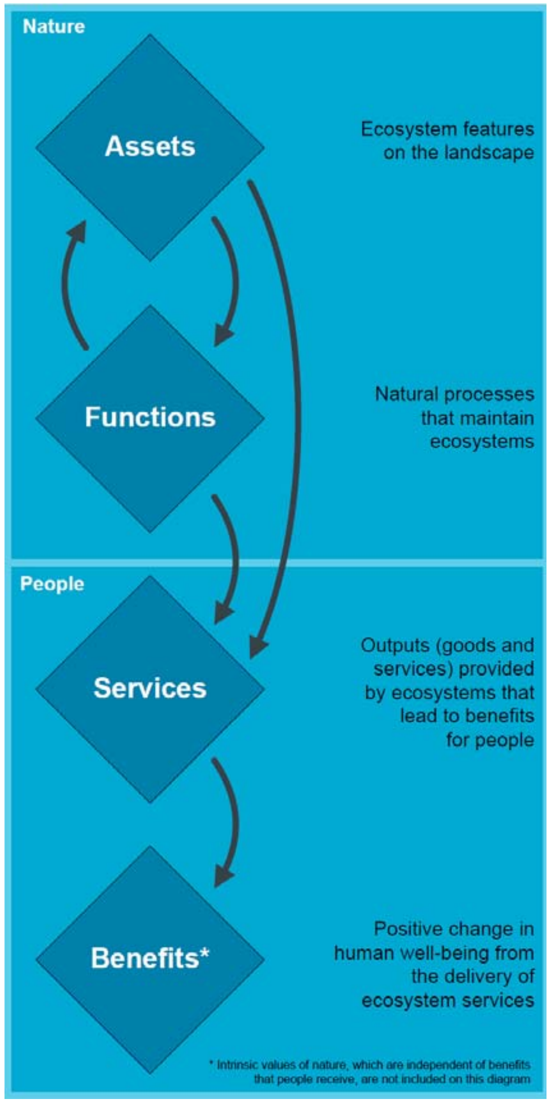


Figure 1.3 Master Ecosystem Services Cascade Diagram

It is noted that ecosystem services and functions do not necessarily show a one-to-one correspondence. In some cases a single ES is the product of two or more ecosystem functions whereas in other cases a single ecosystem function contributes to two or more ES. This lack of correspondence also occurs between scale of ES provision and scale of beneficiaries. For example, local wetlands provide global carbon benefits, regional water quality and local recreation opportunities. In addition, it is important to emphasize the interdependent nature of many ecosystem functions. It is also important to recognize that a minimum level of ecosystem "infrastructure" is necessary in order to allow production of the range of services (Costanza et al., 1987).

Despite continuing losses of wetlands in our case study area, there is a growing recognition that wetlands provide a range of ES that are beneficial to society. This contribution has been recognized by local municipalities either as explicit policy objectives or as part of land use planning process.

For example, the City of Calgary developed a Wetland Conservation Plan that explicitly recognized wetlands as providers of water quality and supply, flood attenuation, erosion control and a variety of socio-cultural benefits (Calgary Conservation Plan, 2004).

There are a number of ES beneficiaries that are produced by case study wetlands and their surrounding areas. Beneficiaries can occur at different scales. For instance residential home owners benefit at the local scale from flood control of a wetland or small wetland complex; however flood control produced by wetlands across the entire case study area can have benefits outside the area to stakeholders such as the City of Calgary and Rocky View County that have to manage flooding within their jurisdictions, or to communities further downstream. In addition, benefits accrue to the provincial government in terms of reduced flood mitigation and compensation costs when flood control is provided free by wetlands.

Through a series of working sessions, the ES Pilot's 'decision-makers' (i.e., wetland approval writers) chose three ES as being the top priority for greater understanding: water storage/supply, flood control and water purification/quality. These three ES were chosen for in-depth assessment from both biophysical and economic perspectives, along with carbon storage which is part of the provincial Climate Change Strategy and related regulations. To obtain a more holistic picture of the benefits derived from wetlands, the Socio-econ Sub-team also investigated some cultural ES quantitatively such as recreation and amenity value in terms of added property value, and qualitatively such as educational and scientific opportunities. These cultural services were also highly recognized by a broader selection of stakeholders (including ES beneficiaries) in other survey responses and workshops conducted by the ES Pilot (see the *'Integrated Results Report'*).

Biodiversity was also identified by multiple stakeholders as being of high importance in wetland management, however, it is not considered to be a standalone ecosystem service in the ES context (see Text Box 2).

Text Box 2 - Is Biodiversity an Ecosystem Service?

The ecosystem services approach is a "utilitarian" concept of nature, in which biodiversity is understood to be a necessary condition for the production of ecosystem services, but not an ecosystem service itself (Ash et al., 2010). Biodiversity underpins the supply of ecosystem services such as seed dispersal, pollination, pest and disease control, and carbon sequestration. Therefore, changes in biodiversity will affect the quality and quantity of ecosystem services available to humans.

Within Alberta the Department of Sustainable Resource Development (SRD) manages biodiversity for the province. SRD has been leading the development of a draft Biodiversity Strategy. Once this strategy is released there will be opportunity to further define the relationship between ES and biodiversity for the Province of Alberta.

1.4 Rationale for Economic Valuation

In a policy appraisal context, valuing ecosystem services can help in determining whether a policy intervention that alters an ecosystem condition delivers net benefits to society; providing evidence on which to base decisions; choosing between competing uses, e.g. of land use; assessing liability for damage to the environment; and in wider communication e.g. to the public and land managers on the value of the environment (DEFRA, 2007). Adopting the ES framework may provide new insights for policy development, for example, in understanding how conservation policies in the future can be best targeted to deliver our environmental priorities. It may also help in creating markets for services, including payments for ES, as valuation provides evidence to underpin the development of such policy instruments.

This broader framework allows a shift in emphasis from a focus mainly on valuing environmental damage to highlighting the value of changes in the services provided by the natural environment. With a broader focus on ES, the value of natural environment is more likely to be considered in decision making.

For the ES Pilot, economic valuation can help address the three prioritized gaps identified by wetland approval decision makers (see Text Box 1, Section 1.1). In the current wetland approval process, wetlands are assessed on an area basis and wetland management decisions are made without any consideration of ES and associated benefits provided by wetlands. In particular, for compensation decisions, restoration cost on a per hectare basis is determined primarily as a function of land cost and the associated cost to restore wetlands. The value of ES and benefits derived from each individual wetland and collectively is not reflected in the wetland mitigation decisions at all. To fill those gaps, results of economic valuation can be a powerful tool to communicate the values of wetlands with different stakeholders that are involved in wetland management process, such as the public, developers, industries, municipalities, and governments at different levels. It can provide evidence to support the mitigation hierarchy of wetland approval process. Assessing the majority of ES provided by wetlands, and how they are valued by people can help decision makers identify priorities for avoidance, minimization and compensation decisions for individual wetlands and plan wetland management at larger landscape scales. Economic valuation can estimate total value and cumulative value losses of wetland ES. Valuation can also estimate future value losses based on the trend assessment of wetland loss on a landscape. This helps to inform the consideration of cumulative effects and long-term consequences of decision making on the landscape.

In order to understand the value of an ecosystem it is necessary to characterise and quantify the relationships between ecosystems and the provision of ES, and to identify the ways in which these impact on human welfare. Such understanding requires an interdisciplinary approach involving range of natural and social science disciplines. As a multi-disciplinary team, the Socio-econ Sub-team members were working together to ensure that ecological, social and economic considerations are taken into account to the fullest extent possible during valuation.

2 Economic Valuation Framework

2.1 Concepts of Economic Value and Valuation

Value is not a single, simple concept. People assign or hold all types of values, e.g. use value, aesthetical value, spiritual value, existence value. Thus, when people talk about environmental values, the value of nature, or the values of ecosystem services, they may refer to these different sources of value. Furthermore, people trained in different disciplines (e.g., ecology, economics, philosophy, psychology) understand the concept of value in different ways (US EPA, 2009).

According to the Oxford Dictionary, there are three main types of "value": (i) *exchange value*, that is, the (relative) price of a good or service in the market; (ii) *utility*, that is, the use value of a good or service, which can be very different from the market price (e.g. the market price of water is very low, but its use value very high); and (iii) *importance*, that is, the appreciation or emotional value attached to a given good or service (e.g. the emotional or spiritual experience some people have when viewing wildlife or natural scenery, or our ethical considerations regarding the existence value of wildlife) (CBD, 2007).

In this study, with the recognition of multiple definitions of *Value* and *Valuation*, we have used the following as our working definition (see *Section 11 Glossary of Key Terms*). Generally, *Value* refers to the worth, merit or desirability of an ecosystem service to human. In *economics*, it is the measure of the wellbeing associated with the change in the provision of an ecosystem service quantified in monetary or other appropriate units. *Economic Valuation* refers to assigning quantitative economic values to ES, including services that are at least partially captured by the market (such as provisioning and some cultural services) and those that are not currently valued in the marketplace at all (for instance, regulating services such as erosion control and climate regulation).

Determining a value for wetland ES can be very straightforward when the service has a market determined value, such as fish, natural medicines, pharmaceuticals, other foods and fibers. However, for a great number of ES, markets do not exist to help establish a price. Economists have come up with a number of techniques to help value these 'non-market' services. There are different types of valuation techniques to elicit the public preference on ES which is discussed in Section 3.

2.2 The Total Economic Value Framework

The value of natural resources is often considered within the framework of Total Economic Value (TEV), which is also applicable in valuing ES. Note that 'total' in TEV framework refers to comprehensive examination of the effect of natural resources on human wellbeing and comprises of use and non-use values (Figure 2.1) .[1] See Appendix 1 for detailed definitions for each of these categories.

[1] Total as defined to be comprehensive is different from total as defined to be additive (see Section 3.1).

Direct use values tend to be the easiest to account for, because they are often part of formal markets, such as the profits from the sale of wetland products. Other values are more difficult to measure. Non-use value are particularly challenging since individuals find it difficult to ‘put a price’ on such values as they are rarely asked to do so. It is typically estimated through stated preference approaches (see *Section 3.2*), in which surveys are conducted of people’s willingness to pay/accept for the value in question.

Given the resource constraints, however, the valuation efforts of this team have been focused on assessing some of the direct and indirect use values of ES derived from the wetlands within the study area. When more resources come available in future, other categories of values, such as non-use values, can be investigated in depth.

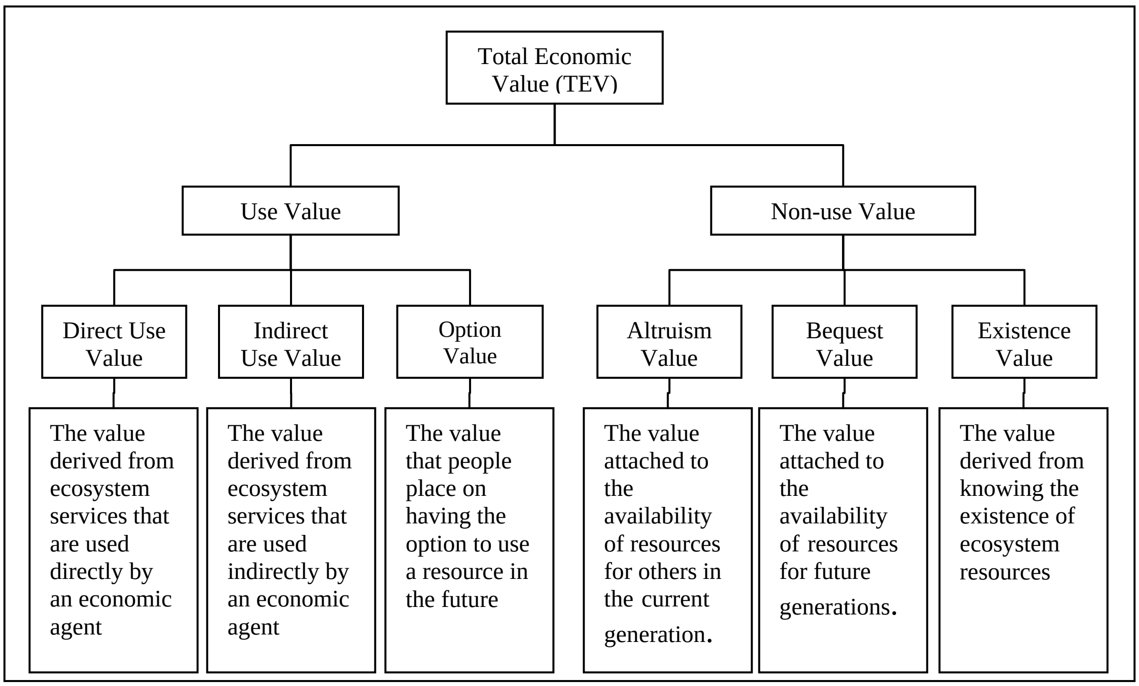


Figure 2.1 The Framework of Total Economic Value
(Adapted from Ash et al (2010); TEEB (2010))

2.3 The Relationship of the TEV and ES Frameworks

The TEV framework and the ES framework for categorizing ES can be seen as complementary (see Table 2.1 and also Figure 3.1). The TEV framework is a useful tool for exploring what types of values for each ES we are trying to elicit. This helps in determining the valuation methods required to capture these values.

Table 2.1 Valuing Ecosystem Services through the TEV Framework (N.A.=Not Applicable)

ES Framework	**TEV Framework**			
ES Category	Direct Use	Indirect Use	Option Value	Non-use Value
Provisioning services	*	N.A.	*	N.A.
Regulating services	N.A.	*	*	N.A.
Cultural services	*	N.A.	*	*
Supporting services	Valued through the other categories of ES to avoid double counting			

(Adapted from UK DEFRA (2007); TEEB (2010))

It needs to be emphasized the distinction between intermediate and final services (Fisher et al., 2008). *Double Counting* may arise when a service is valued at two different stages of the same process providing human welfare. If both services are given an economic value, the benefits obtained from that ecosystem can be overvalued. Supporting services are defined as intermediate services and should be accounted for through impacts on other ES and therefore not valued separately in this study. This approach is consistent with the literature (e.g Chiabai et al. 2009; Ojea et al. 2010b). Other ES could be intermediate or final services depending on what economic end point is in question. For example, for angling, water quality is an intermediate service in the provision of fish, whereas for drinking water, water quality is a final service (UK DEFRA, 2007). To the extent possible, we have attempted to distinguish intermediate and final services to avoid double counting.

3 Economic Valuation Techniques

3.1 Types of Value Measures

There are three types of economic value that can be calculated: total, average or marginal value for each of the value categories under the TEV framework. In deriving value estimates *Total Value* refers to the sum of values associated with units of a resource, *Average Value* refers to the sum of the value divided by units of a resource, and *Marginal Value* is the change in value associated with change in the number of units.

In general, total value is applicable when considering alternative uses for the entire resource. For example if all of the wetlands in the study area were to be lost due to land use changes, total value approach can be used to estimate this loss of value. Average value would simply be the total value lost divided by the total area lost. Marginal value approach assesses change in value resulting from one unit of resource change. Bateman (2010) recommends marginal value analysis approach since very few policy decisions relate to total loss of ES. Further, Bateman argues that it is more important that policy changes require an understanding of the value of changing a single unit of resource.

Although marginal valuation approach is recommended its use is limited by two factors: reliance on relatively stable systems upon which valuation exercises are conducted and data availability. Marginal value can change drastically from one unit to another. It is important to understand how marginal value may change as units of the ecosystem are altered, whether it is increasing, decreasing or greatly affected by a critical threshold. Increasing marginal values would indicate that the less of the resource the more valuable the remaining units are, which is the most case. An example for the purpose of a wetland ecosystem might be recreational value. As each hectare of wetland is developed, recreation use will become more concentrated in the remaining undeveloped areas making each remaining hectare more valuable.

Decreasing marginal values would suggest that on a per unit basis the first units to be developed would result in the biggest loss of value. If the entire ecosystem's main value is derived from the fact that it is used a water drainage system and the removal of one unit would render that function disproportionately less serviceable.

The last aspect of marginal values is if a critical *threshold* (irreversible changes occur) is crossed. In this scenario marginal value may be relatively constant before and after the threshold but a large change of value would occur on the marginal unit that crosses it. For example, for a wetland that provides the habitat for an endangered species, reducing the size of this ecosystem to the point where it no longer can support this particular species would be the point where most of its value is lost.

However, in valuation practices, it is difficult to estimate marginal values of ES due to lack of methodology approach that show how marginal changes in ecosystems result in marginal changes in human wellbeing. It is not always the case that one unit change in ecosystem leads to similar change in human wellbeing since interaction between them can be non-linear. For these reasons valuation researchers often use average and total values. With the exception of amenity value, where the method allowed estimation of marginal value, the value calculated in this study uses total or average value approach. Depending on the ES, some values were estimated at individual wetland level while others were estimated at a broader sub-watershed or study area boundary level.

3.2 Identification of Valuation Methods

Economic valuation attempts to elicit public preferences for changes in ecosystem services, mostly in monetary terms. Valuation approaches can be organized into *Revealed Preference* and *Stated Preference* methods (see *Appendix 2* for details). The valuation methods discussed in this section are not new in themselves. The challenge is in their appropriate application to ES. The ES framework emphasizes the need to consider the ecosystem as a whole, and stresses that changes or impacts on one part of an ecosystem have consequences for the whole system. Therefore, considering the scale and scope of the services to be valued is vital to get any meaningful value estimates.

Table 3.1 Summary of Economic Valuation Methods

Valuation Method	***Description***
Revealed Preference Methods	
Market prices	The exchange value (based on marginal productivity cost) that ecosystem services have in trade. Used where market prices of outputs (and inputs) are available.
Production function	Measure impact of change in ecosystem condition on the produced goods.
Travel cost methods	Costs incurred in accessing a recreation site as a proxy for the value of recreation. Part of the recreational value of a site is reflected in the amount of time and money that people spend while traveling to the site.
Hedonic pricing methods	Derive an implicit price for an environmental good/service from analysis of goods for which markets exist and which incorporate particular environmental characteristics. Hedonic pricing has the potential to value certain wetland functions (e.g., storm protection, groundwater recharge) in terms of their impact on land values, assuming that the wetland functions are fully reflected in land prices.
Avoided damage cost	Model comparison of the damages avoided by having protection against natural disaster that would have been incurred in the absence of those services such as flooding.
Replacement cost	Potential expenditures incurred in replacing/restoring the function that is lost; e.g. by the use of substitute facilities or "shadow projects". Depends on the existence of relevant markets for the ecosystem service in question. Examples include man-made defences being used as proxy for wetlands storm protection; expenditure on water filtration as proxy for value of water pollution damages.
Cost of illness or morbidity (human capital approach)	Calculates the equivalent value of the loss of earnings or life that would result if the service were not effective.
Stated Preference Methods	
Contingent valuation	Construction of a hypothetical market in surveys for a sample of individuals, asking them to directly state their preferences, e.g. how much they would be willing to pay (or accept as compensation) for specific services.
Contingent behaviour	Construction of a hypothetical scenario in surveys for a sample of individuals, asking them to directly state their behaviour changes.
Contingent ranking	Individuals are asked to rank several alternatives in surveys that comprise various combinations of environmental goods and prices.
Choice experiment (conjoint analysis)	Ask people to make choices based on a hypothetical scenario in surveys. Values are inferred from the hypothetical choices or tradeoffs that people make.
Other Methods	
Benefits transfer (unit-value/function transfer)	Take evidence on the value of benefits/damages from one context (e.g. other similar areas) and transfer it to another context (the study area).

(Source: Turner et al (2004); Renzetti (2002); Young and Gray (1972); Ash et al (2010); UK DEFRA (2007); TEEB (2010))

3.3 Assessment of Valuation Methods

Table 2.1 illustrated how the TEV framework can be a useful tool for exploring what type of value we are trying to elicit for each ES. Table 3.1 provided a general overview of economic valuation methods. This helps in determining the valuation methods required to capture these values. The methods identified differ in a number of important respects, such as the underlying assumptions and concepts of value they seek to measure or characterize; the empirical and analytical techniques used to apply them; their data needs (inputs) and the metrics they generate (outputs); their involvement of the public, etc (US EPA, 2009). The applicability of these methods is reviewed in this section in the context of specific ES categories. For certain ES, only some valuation methods may be applicable. For example, market prices are often used for valuing provisioning services, while stated preference studies are well suited to capturing non-use values (e.g. existence value of rare species). In addition, not all methods capture all elements of TEV. These points are summarized in Appendix 3, along with their advantages, limitations and timelines required for each method.

Figure 3.1 shows the relationship between TEV and ES categories along with commonly used valuation techniques for each category. Some methods may be more suited to capturing the values of particular ES than others. In many valuation contexts, more than one technique is likely to be employed to assess the values of different ES categories. The method(s) used very much depend on the services being valued and their context, and should be selected with various considerations.

Stated preference techniques can, in principle, be applied to any context; however, they can be limited by the ability of respondents to understand the nature of the service. If the relationship between cause and effect for many complex ES is not well understood, respondents in a valuation exercise may not well appreciate the impact that an ES might have on their wellbeing (UK DEFRA, 2007). It’s usually a more resource-intensive method compared to others.

While cost-based techniques need to be used with care, these approaches can offer a pragmatic approach to valuation. Such techniques are seen to have widespread relevance in valuation of ES, particularly in the case of valuing changes in regulating services. In particular, replacement cost methods were conducted in this study in valuing flood control and water purification benefits while other methods were also applied when appropriate.

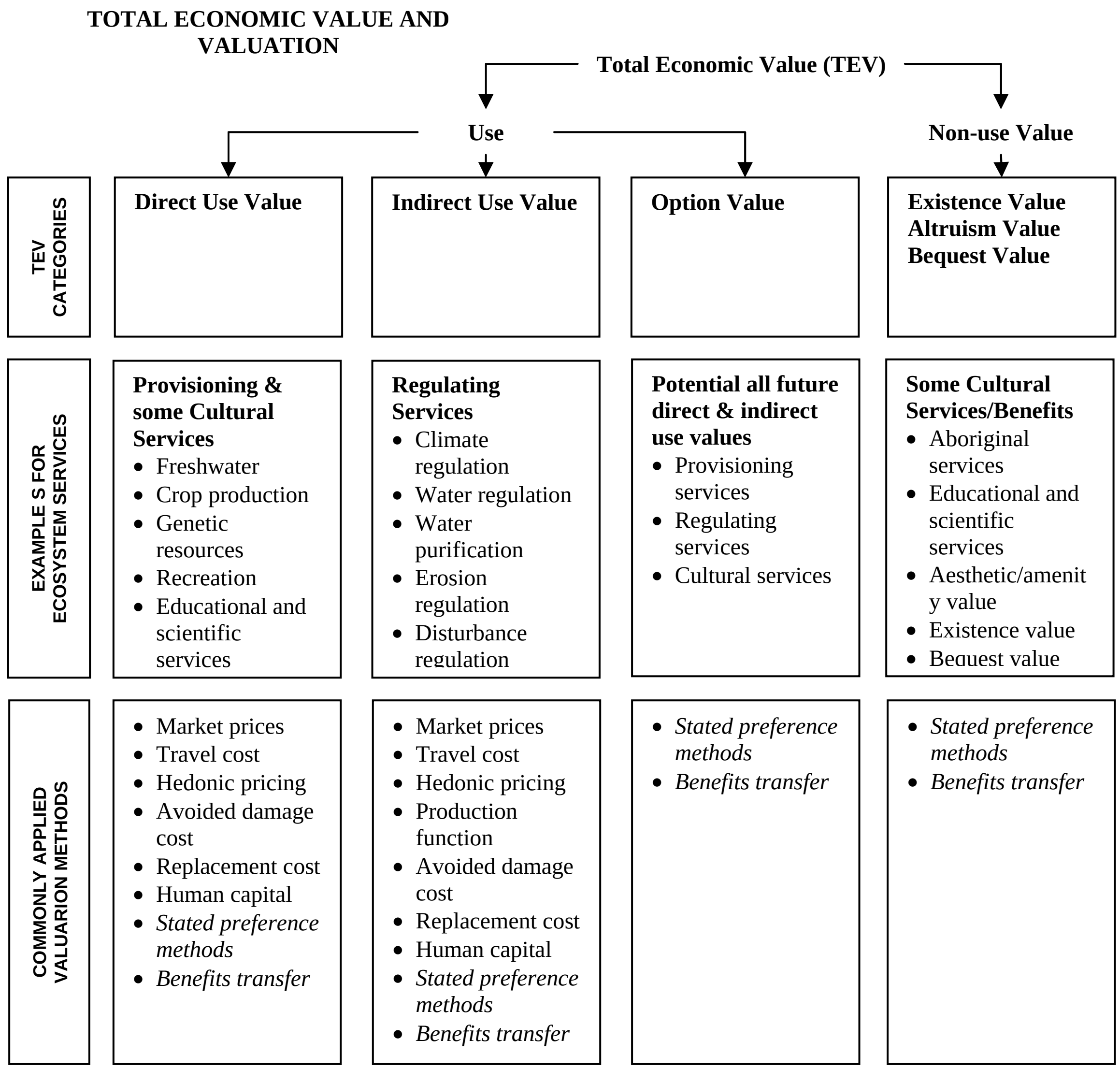


Figure 3.1 Total Economic Value and Valuation Methods
(Adapted from CBD (2007); UK DEFRA (2007))

4 Criteria for Choosing Methods

When conducting a valuation study, it is necessary to balance the benefits of using the best scientific techniques with the financial, data, time and skills limitations. Generally, the valuation methods chosen depend on the characteristics of ES to be valued, the scope of the study, the quantity and quality of data available, as well as the time and other resources available. There is always a trade-off between the validity or reliability of data and the necessary effort to gather data and information.

The team develops a set of criteria to evaluate methods prior to use in valuation. This assists the research team not only in determining when methods are suitable but also in determining where to invest scarce resources. These criteria not listed in order of importance include:

- Theoretical credibility. A primary consideration in evaluating a method should be the extent to which the method seeks to elicit or measure a concept of value that has a consistent and transparent theoretical foundation appropriate for the intended use. Different valuation methods measure different concepts of value. For a method to be appropriate in a valuation context, it must seek to measure a concept of value that is well-defined, theoretically consistent, and relevant for the particular valuation context (US EPA, 2009, pp.41).
- Validity. Another over-arching criterion for evaluation is validity – i.e., how well the method measures the underlying construct that it is intended to measure. The team should use criteria to assess the extent to which a given method is likely to yield a measure, or at least an unbiased estimate, of the underlying construct of value (US EPA, 2009, pp.41).
- Relevance. Methods can also be evaluated on the extent to which the resulting value estimates can be transparently communicated in a useful format to those who will use the value information. Decision makers, stakeholders and the public should be able to understand how the value measures relate to and inform the decision that needs to be made (US EPA, 2009, pp.43). The estimates should be tied into supporting the filling of the three gaps identified in the pilot project. A consideration should also be whether total value or marginal value is needed so that these values are relevant for different purposes, e.g. cases where trade-off decisions are involved and where total values are desired. A further consideration is which method is appropriate to yield marginal values and which can get total values, or how WTP questions can be asked to yield marginal value and total value responses.
- Data availability. Data requirements may be quite demanding for a number of methods that are data intensive. Both quantitative and qualitative data may be needed for certain methods. With a high quality and quantity, data needs to be accessible and reliable for the purpose of economic valuation practice. The economic valuation requires both socio-economic and biophysical data on wetlands, along with a clear understanding of the effects of ES on human welfare.
- Resource constraints, e.g., time, finances and skills. Some methods are more resource intensive than others. Resource constraints affect which characteristics can be valued and with what degree of accuracy. It will also determine which data collection methods are appropriate and how they are implemented. Resource constraints and data collection options will influence the choice of valuation techniques to be selected. Conducting primary valuation studies is typically time-consuming and costly. Given the specific timeline for this project, second best methods may be chosen at the current phase of the project, with recommendations captured in the lessons learned for future projects.
- Replicability. Develop estimates based on existing data and information systems and available skill sets (staff capacity) whenever possible. Making use of information routinely collected by existing institutions increases the likelihood of similar valuations being implemented in the future, allowing examination of

change over time. In addition, some methods require more specific and more sophisticated expertise to undertake them than others. For instance, surveys can provide valuable information, but are somewhat subjective, and may be one-time events, unless there is capacity to repeat the survey in the future. However, this does not denote the application of benefits transfer.

- Integration/linkage to other components of this project, in particular the biophysical and socio-cultural components. The determination of methods should also consider the integration among the three pillars of economic, biophysical and socio-cultural components of wetland values.

5 Economic Values: Selected Ecosystem Services

This section focused on the priority ES identified in the ES Pilot, which are **water storage/supply, flood control and water purification/quality**, along with **carbon storage**. Some cultural ES were also assessed quantitatively such as **recreation** and **amenity value** in terms of added property value, and qualitatively such as educational and scientific opportunities. These cultural services were highly recognized by a broader selection of stakeholders in the pilot. If time and resources allow, the valuation could be expanded to a broader suite of ES.

5.1 The Value of Flood Control

5.1.1 Introduction

Wetlands play a crucial role in mitigating floods via their natural 'sponge' function (e.g. Potter, 1994; Zedler, 2003, IUCN, 2006). In case of excessive rainfall related flood discharges, wetlands may function as natural sponges playing an important role in the detention and retention of water. They can store (as a basin or depression) and/or delay floodwaters, e.g. by increasing resistance to water flow (hydraulic resistance) as a result of vegetation density and morphology or by absorbing water in soil. This can reduce the height of flood peaks (detaining floodwater during peak flow, extending the period over which a flood takes place) or reduce the overall volume of floodwaters (retaining water from the surface flow system downstream) passing downstream. Where a series of wetlands functioning in this way occur in the same basin but in different tributaries then this can have a strong cumulative effect further downstream where these tributaries combine. This service is strongest in wetlands located in floodplains where direct interaction with floodwaters can take place. However, upstream wetlands on slopes and plateaus can also regulate floods by detaining or even retaining floodwaters from reaching river channels and contributing to flood events. In addition wetlands regulate the frequency of drought periods. During periods with no rainfall some wetland types can continue to supply small tributaries with water and keep them from falling dry (Baker and van Eijk, 2006).

Water retention and avoiding costs of storm runoff impacts is an important asset to the well-being of people living in the study area, as well as others outside of the area who benefit from the integrity of the ecosystem. Wetlands help protect adjacent and downstream properties from potential flood damage. The value of flood control by wetlands increases with: (1) wetland area, (2) proximity of the wetland to flood waters, (3) location of the wetland (along a river, lake, or stream), (4) amount of flooding that would occur without the presence of the wetlands, and, (5) lack of other upstream storage areas such as ponds, lakes, and reservoirs (Mitsch and Gosselink, 1993). Wetlands within and upstream of urban areas are particularly valuable for flood protection. The impervious surface in urban areas greatly increases the rate and volume of runoff, thereby increasing the risk of flood damage. The flood mitigation benefit occurs at several scales; this report focuses on local (within the study area) and regional (Bow basin downstream of the Shepard outlet to Bow).

Localized flooding has been identified as an issue within the study area (AECOM, 2011b; O2 Planning and Design, 2011). There are some flooding issues, particularly within the Shepard industrial area due to massive land cover alterations; however no specific tracking system has been dedicated to this area as responses have been made on an incident-to-incident basis (Jiang, 2011). In the past ten years, flood risk in this area has increased, especially with addition of industrial and residential development; however, it is not consistent across the whole area (Jiang, 2011). There are reports that several severe floods occurred within this area (O2 Planning and Design, 2011). It is noted in the 2001 Shepard Plan (City of Calgary and Rocky View County, 2001) that the Hamlet of Shepard is located in an area with a high water table, a history of flooding and water quality issues. Stakeholders have expressed concern about flooding, flooding protection, high moisture problems, high water tables, water wells and also road drainage. There are no significant established natural drainage courses to convey stormwater flows across the region, which adds to the complexity of stormwater management in this region. The general drainage direction is from north to south, and the major drainage features include the Shepard Slough Complex and the Shepard Ditch (AECOM, 2011b).

Some of the historical flooding is likely natural, due to the predominance of wetlands and a high water table (O2 Planning and Design, 2011). However, it is well established that the existence of wetlands at one location reduces flooding down gradient at other locations (O2 Planning and Design, 2011). In many cases, wetland drainage and development can cause hydrological changes and undesirable local flooding that was not present prior to development. In prairie pothole landscapes, if large development footprints are installed, there will be unavoidable increases in discharge rates from property parcels pre and post development. For example, the established discharge rate of 0.8 L/s/ha in the area (AECOM, 2011b), although fairly low by urban development standards, is higher than a typical prairie pothole non-contributing drainage area, which will, under normal circumstances (1:2 year events), contribute no flow at all downstream.

Another issue to consider is that, in some cases, irrigation canals bisecting the study area can rupture or leak into adjacent properties. For example, the Western Irrigation District (WID) “A Canal”, which begins in the study area near the SE corner of Lake Chestermere, has previously been observed to have collapsed in over 50 locations, permitting water to escape and flood adjacent areas (O2 Planning and Design, 2011). Without wetlands and other open space present to help absorb this unpredictable infrastructure failure, property or crops will flood instead. The Town of Chestermere has identified a “Drainage Constraint Area” on the southern and eastern ends of Lake Chestermere, where potential flooding would occur following a dam breach or overtopping from Lake Chestermere (O2 Planning and Design, 2011). They also state that “ Development proposals in this area will need to address the Drainage Constraints to the satisfaction of the Town and the Western Irrigation District.” Therefore, wetlands within this Drainage Constraint Area, of which there are several, may be able to absorb some of this potential flooding and therefore provide a high potential for ecosystem service economic values for flood control.

Rocky View County identifies the study area as one of the potential flood risk areas and ensures that any development is well aware of risks and produces the appropriate stormwater management plans to attempt to mitigate some of the risks. Developments need approvals to ensure that pre-development and post development flows are equivalent and permitted (zero discharge rate), remediation and engineered wetland standards, classification of wetlands and compensation requirements and enforcement for illegal pumping and filling (Jiang, 2011).

The City of Calgary has also identified a Floodplain[2] Map[3] for communities of high flood risk (see Figure 5.1). As snow melts in the Rocky Mountains and combines with heavy rainfall, people in low-lying areas (or flood plains) may be impacted by flooding. These areas include communities near the Bow and Elbow rivers. As noted from the map, a very small portion of the area in the south part of our study area (south of Marquis of Lorne TR SE, north of Bow River) has been identified as one of the high-risk floodplain communities[4]. This area is currently dominated by agricultural land.

Acknowledgement of wetland benefits is evident in the design and development of developments occurring in the Shepard Slough area. These developments have modified existing wetlands to manage storm water and nutrient runoff. Agricultural areas are not specifically required to manage storm water and nutrient runoff but management practices are promoted to minimize runoff into water bodies. Ultimately however, runoff interception by wetlands is expected. The City of Calgary also recently completed the Shepard Constructed Wetland that will assist managing storm water runoff from a catchment area of nearly 6,000 hectares of existing and future sources before eventual discharge to the Bow River. This wetland was constructed at a site of existing ephemeral wetland that has been enlarged and modified to meet the storm water need. It should be noted that this modification of wetland for storm water management can come at the expense of other ES that wetlands had provided prior to modification. Thus, an assessment of ES gained relative to ES lost from modification should be conducted to ensure net overall benefit of a wetland.

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[2] Floodplain includes those lands abutting the floodway that would be inundated by floodwaters in the event of a flood of a magnitude likely to occur once in one hundred years. (City of Calgary website: http://calgaryonlinestore.com/detail.asp?prod_id=2639, accessed on Aug.29, 2011)

[3] http://www.calgary.ca/UEP/Water/Documents/Water-Documents/Floodplain_CITY_8x10.pdf accessed on Aug. 29, 2011

[4] http://www.calgary.ca/UEP/Water/Documents/Water-Documents/Southeast_Sector.pdf accessed on Aug. 30, 2011

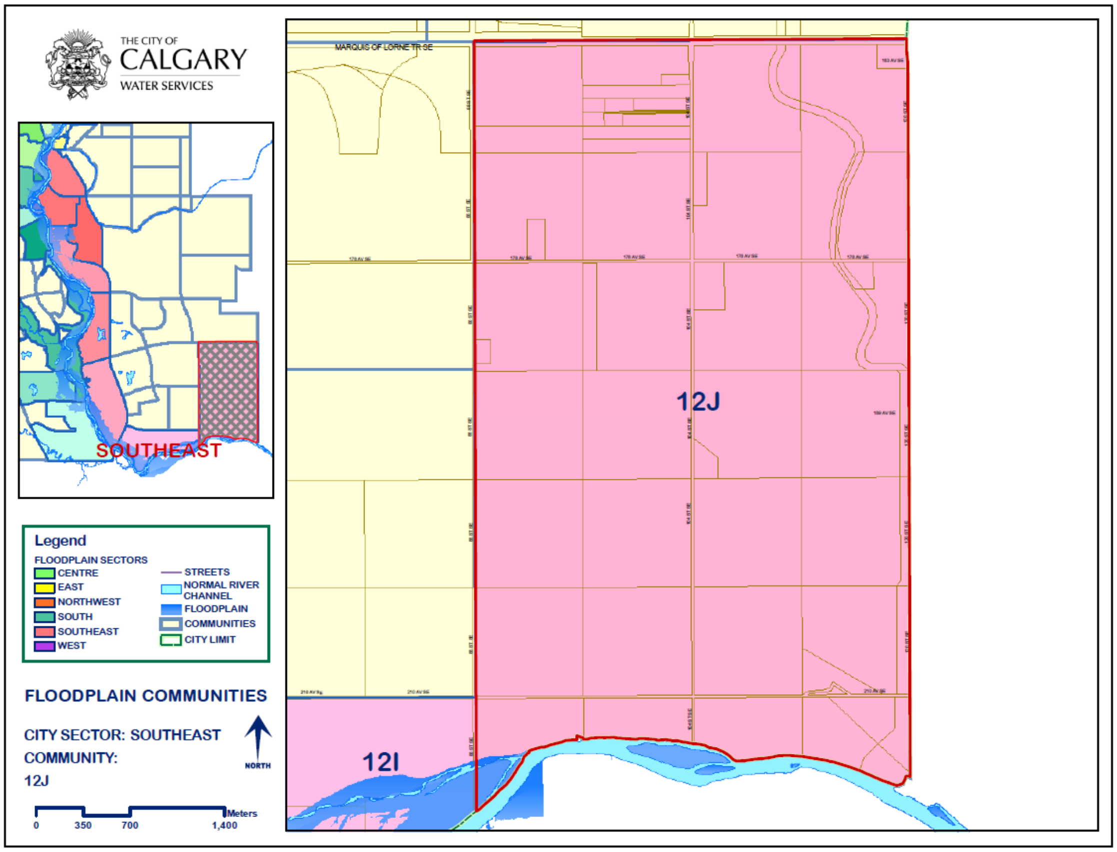


Figure 5.1 The City of Calgary Floodplain Map

5.1.2 Methodology

The flood mitigation benefit examines the role wetlands plays in attenuating flooding. There are several ways to measure the flood control benefits from wetlands (Figure 5.2). Two value categories were investigated here. In the first value category, the indicators for local scale benefit include avoided flooding on land and property while regional scale benefit is measured as change in flood risk to downstream areas. In the second category, the replacement cost approach could be used to measure the cost of alternative engineering solutions. Developments in Shepard Slough are modifying existing wetlands for storm water management; replacement cost approach calculates the value of constructed wetlands if existing wetlands were unavailable for storm water management. In addition, wetland restoration cost is presented as the baseline cost of maintaining existing wetlands to provide the same amount of benefits.

In addition to local storm water management, wetland benefits are often assessed in the context of reduced cost of flood mitigation facilities because wetlands provide water retention that would have occurred otherwise. Flooding and associated flood damage has been traditionally addressed through structural measures such as dams, levees, dikes, and channel improvements. Structural approaches to flood mitigation can certainly reduce or prevent flood damages for an abundance of flood events. The costs of performing conventional structural approaches can also be presented for comparison.

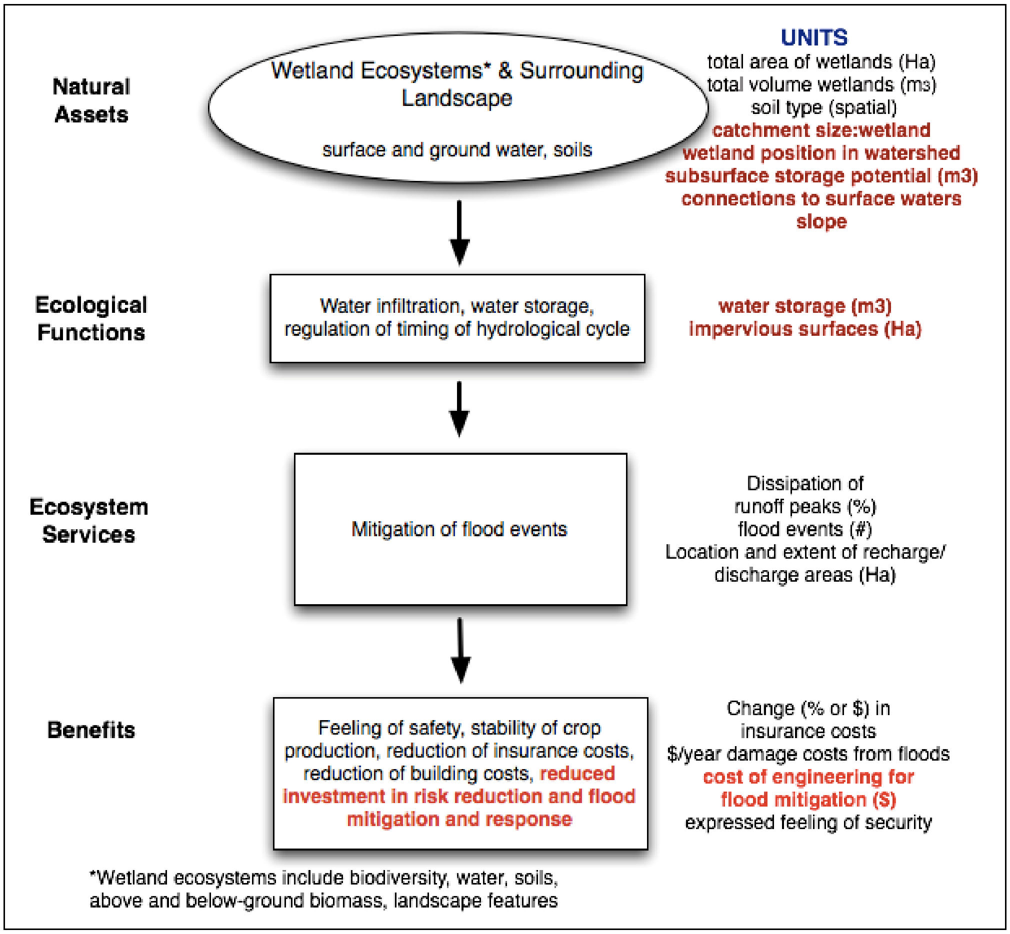


Figure 5.2 Ecosystem Services Cascade: Flood Control

5.1.3 Data Collection

The degree of impact or alteration of the natural wetland influences the cost of successful restoration. Soil replacement and grading can increase the cost of restoration over that of simply preparing the existing soil and planting. Site-specific factors, such as slopes, water currents, or plant species required, can also influence the cost of wetland restoration. Land acquisition cost also contributes to the restoration cost significantly. Based on the historic data on wetland restoration cost from Ducks Unlimited (DU) (2005-2011), 304.91 hectares of loss or impacts to wetland habitat have been granted in the approvals. Through varying ratio splits and associated onsite credits, 911.44 hectares of wetland habitat have been restored to compensate for these losses/impacts. The total expenditure allocated is $7,099,537 to date, which yields the average restoration cost of $7,789 per ha at the site of restoration. In Alberta, the compensation rates are set by AENV. In Calgary, based on a standard 3:1 replacement ratio as per the provincial *Wetland Compensation & Mitigation Guide*, the cost is $17,500 per ha for restoration at the site of restoration. This estimate is within the range estimated by White (n.d) of $8,645 to $197,600 per ha. The cost includes land securement (generally via a conservation easement), restoration costs, long term management costs and a 10 per cent administration cost. Any variance in that cost is usually due to the land securement costs, which tend to be lower when further away from a major urban centre. The restoration costs are considerably less expensive than constructing artificial wetlands of the same size (Scott, 2011). However, most of the historic restoration practices by DU are off-site restorations, which usually take place in rural areas away from urban centers. If restorations occur at the sites of impact, in this case, within the study area, this will substantially inflate the cost of restorations due to much higher costs of land acquisition proximate to the City of Calgary. As a result, the average restoration cost of $17,500 per ha should be considered as the lower bound of estimate as well as the total restoration cost estimate.

Conventional stormwater management systems are very expensive to design and build. For example, the total cost of future stormwater servicing for planned infrastructure in the study area is $270 million (AECOM, 2011b); this does not include expenditures to date which likely number many tens of millions of dollars already. To enable continuing development within the study area while mitigating flooding and drainage issues, the City of Calgary built the Shepard Stormwater Diversion project, which cost approximately 58 million. It is worth noting that the loss of wetland cover and installation of impervious surfaces north of the WH Canal is what ultimately caused the documented flooding problems in the irrigation canal system itself. As the bypass structure only deals with a limited quantity of peak flow (16 m^3/s maximum capacity), the full replacement cost of flood control services of all wetlands north of the canal is likely much higher since additional bypass structures would need to be built in the future. The total cost of building stormwater management systems for the loss of the wetlands north of the WH Canal will eventually be higher than $328 million, a sum of the total cost of the projected infrastructure requirements of additional drainage shown in AECOM (2011b) ($270 million), and the existing expenditures related to the Shepard Stormwater Project ($58 million). This may still be on the low end since expensive stormwater systems such as pipes and stormwater ponds will also still need to be integrated into new developments on top of the drainage infrastructure in order to meet the low runoff release rate targets that have been established for the area so that downstream conveyance channels will be able to handle increased stormwater flows without requiring additional expansions (O2 Planning and Design, 2011).

The Shepard Constructed Wetland, with 230 hectare and built from 2007-2009, is designed to manage and treat storm water before eventual discharge to the Bow River. It receives storm water runoff from a catchment area of nearly 6,000 hectares of existing and future sources on the east side of the City of Calgary. This wetland has a maximum storage volume of nearly seven million cubic meters. On a unit area basis the Shepard Constructed Wetland is capable of storing about 27,000 m^3/hectare. Under normal operating conditions the water retention time is about 72 days (Chivers et al, 2011). The total cost of the project was $58 million, or about $252,000 per hectare[5]. This estimate is within the range estimated by White (n.d) of about $86,450 to $370,500 per hectare for constructed treatment wetlands. The cost of constructed wetlands is proportional to the number and sizes of treatment cells required. Initial construction

[5]The land acquisition cost is assumed to be included in the total cost. If not, then the per hectare cost of constructed wetland is underestimated, which also indicates our estimates of total value of wetland in terms of flood control are underestimated as well.

costs of wetlands are relatively low compared with traditional water retention solutions. Because the wetlands require little maintenance, long-term costs are also quite low.

O2 Planning and Design (2011) provided an estimate of water storage capacity of existing wetlands in the Shepard Slough (36.3 million m^3) and also a breakdown of water storage capacity into W4 subwatershed. Per hectare water retention capacity of Shepard Constructed Wetland was applied to O2 Planning and Design (2011) derived water volume data to estimate the total area required to build constructed wetlands. Also an annual loss of wetlands occurred in this area was applied to estimate the annual change in value of flood control benefits. According to Badiou (2011a), in 1962 there were approximately 1,980 ha of wetlands (class 3-5) and this decreased to 1,484 ha in 2005, for a total change of 496 ha. This is equivalent to a 25 per cent loss in wetland area between 1962 and 2005 or approximately 0.6 per cent per year.

Flood risk to downstream areas was evaluated using two data sources, Alberta Environment and Sustainable Resource Development Flood Hazard Mapping and Alberta Environment and Sustainable Resource Development River Forecasting Section. The Flood Hazard Mapping did not indicate areas that are considerable distance downstream of Shepard Slough that was considered to be in flood hazard for a 1:100 year flood[6]. One limitation of this map however, is that only at risk properties like human infrastructure are assessed for flood risk. It is possible for downstream areas to experience flooding but not be considered within the Flood Hazard Mapping. This project did not address this gap in knowledge. Another measure to assess flood risk can be done by comparing the flood return period with change in hydrology. The projected flow into the Bow from Shepard Slough is expected to be 29 m^3/s when the Shepard Ditch and other drainage is at full capacity (O2 Planning and Design, 2011). The 1:100 return period for the Bow downstream of Calgary is estimated at 3,110 m^3/s, thus, Shepard Slough would add less than one percent to the flow. For a 1:2 return period of 413 m^3/s the Shepard Slough would add about 7 percent to the flow. The addition of flow from Shepard Ditch is not expected to alter the flood risk in the Bow in the context of existing river hydrology (Choles, 2011). In an extreme situation where all wetlands were drained, the projected discharge rate would be 134 m^3/s (O2 Planning and Design, 2011), which would add 4.3 percent to the Bow river flow under the 1:100 return period.

Since a large proportion (57%) of our case study area is agricultural land, flood risk has been of a concern for the agricultural production as well. From 2000 to 2010, the insurance payments sum to $385,715 for the agricultural loss, including $191,991 for the unseeded loss in the spring as a result of too much moisture and $193,724 for the flooded loss in the fall during harvest (Cruickshank, 2011).

5.1.4 Results and Discussion

Local flood control was evaluated based on the Shepard Constructed Wetland data. On a unit area basis it is capable of storing about 27,000 m^3/hectare. The total cost of the project was $58 million, or about $252,000 per hectare. In order to value the flood control benefit provided by existing wetlands in the study area, these wetlands were

[6] 1:100 year flood means a flood event that has the likelihood of reoccurring once in hundred years.

assumed to be replaced by constructed wetlands. O2 Planning and Design (2011) provided an estimate of water storage capacity of existing wetlands in the study area (36.3 million m^3). Per hectare water retention capacity of Shepard Constructed Wetland was applied to the derived water volume (36.3 million m^3) to estimate the total area required to build constructed wetlands. This area was estimated at 1,339 hectares. To mimic the flood control services provided by all wetlands in the study area, the cost of conventional stormwater management systems is difficult to estimate. To simplify it, multiplying the per hectare value from Shepard Constructed Wetland by the estimated 1,339 hectares yielded the replacement cost of about **$338 million.** However, it is unlikely that all the wetlands would be lost in a single year. Therefore, an annual loss was applied to estimate the annual change in value of flood control benefits. Using historic (1962 to 2005) annual loss of approximately 0.6 per cent (Badiou, 2011a), this loss was estimated at almost **$2 million.** However, wetland loss is likely to increase in the future due to rapid pace of developments. Assuming doubling of the annual wetland loss, the annual value loss is estimated at about **$4 million** (Table 5.1).

The restoration costs of existing wetlands are calculated based on the total wetland area of 2,450 hectares multiplied by the average restoration cost of $17,500 per ha at the site of restoration for the Calgary area. This yielded an estimate of **$43 million** for total restoration costs. However, it may be an underestimate of the real restoration cost as it only accounts for the cost of off-site restorations which usually occur some distance from urban area (the site of impact). The cost of restoration, should it be done within the study area, would be much higher due to high land acquisition costs proximate to the Calgary area. Also the land cost can be expected to rise in future. It is unlikely that all the wetlands would be drained in a single year. Therefore, an annual loss was applied to estimate the annual change in restoration costs. Using historic (1962 to 2005) annual loss of approximately 0.6 per cent (Badiou, 2011a) and projected annual loss of 1.2 per cent, the restoration cost was estimated at **$257,250** and **$514,500**, respectively (Table 5.1).

Table 5.1 Values of Flood Control and Annual Value Loss for the Study Area

Water Retention Option	Total Value ($)	Annual Value Loss (0.6% annual wetland loss)	Annual Value Loss (1.2% annual wetland loss)
Wetland restoration	$42,875,000	$257,250	$514,500
Constructed wetlands	$337,782,769	$1,982,596	$3,965,192

Figure 5.3 presents a breakdown of total value of wetland water storage in W4 sub-watershed in terms of replacement costs for constructed wetlands. According to O2 Planning and Design (2011), there are a total of 14 W4 watersheds occurring within the study area. Figures 5.4 and 5.5 shows the annual value loss of wetland water storage at the historic and projected loss rates.

Values of flood control in terms of water storage capacity according to wetland sizes were also analyzed. Table 5.2 shows values in terms of replacement costs for constructed wetlands according to several wetland size class intervals. It is clear that, in the study area, most water storage occurs in just a few very large (>10 ha) wetlands. However, wetlands between 0.1 and 1.0 ha account for over eight per cent of the total, which, although small, is almost as high as the total of those wetlands between 5 to 10 hectares (O2 Planning and Design, 2011). Therefore, from a cumulative effects perspective, small wetlands do collectively provide significant benefit. These benefits are valued at about $27 million.

Table 5.2 Values of Flood Control by Wetland Area Class Intervals

Variable	Wetland Area Class Intervals (ha)						
	<0.1	**0.1-1**	**1-2**	**2-3**	**3-5**	**5-10**	**>10**
Total number in study area	4647	1520	200	75	45	45	43
Total volume in study area within size class (million m^3)	1151	2956	1802	1333	1417	3081	24,590
% of total study area volume	3.20%	8.10%	5.00%	3.70%	3.90%	8.50%	68%
Total value within size class	$11 million	$27 million	$17 million	$12 million	$13 million	$28 million	$225 million

However, there are several data limitations in assessing local flood control benefits of wetlands in a more quantitative manner (O2 Planning and Design, 2011):

- There is no 1:100 year floodplain data available within the study area.
- Quantifying which properties are protected from localized flooding due to the existence of wetlands is very difficult without a detailed hydraulic model that indicates where flood flows are routed during extreme events.
- When wetlands are removed, the current regulatory system requires stormwater management systems that prevent flooding through release rate targets and conveyance infrastructure; residual impacts to hydrology or the chance of stormwater infrastructure failure causing destructive flood damages are both very difficult to quantify objectively.

Figure 5.3 Total Value of Wetland Water Storage by W4 Subwatershed

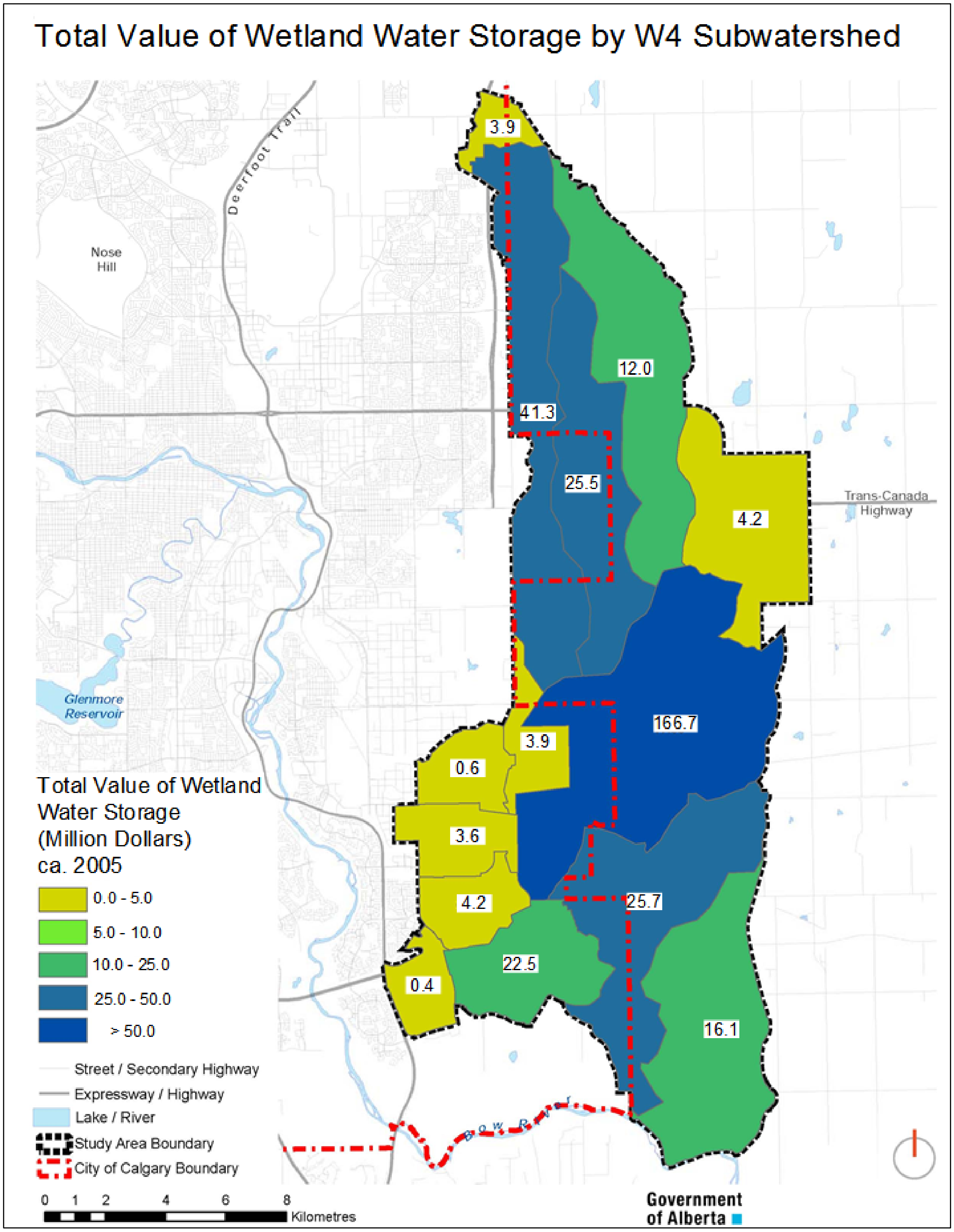


Figure 5.4 Annual Value Loss of Water Storage by W4 Subwatershed (Historic, 0.6%)

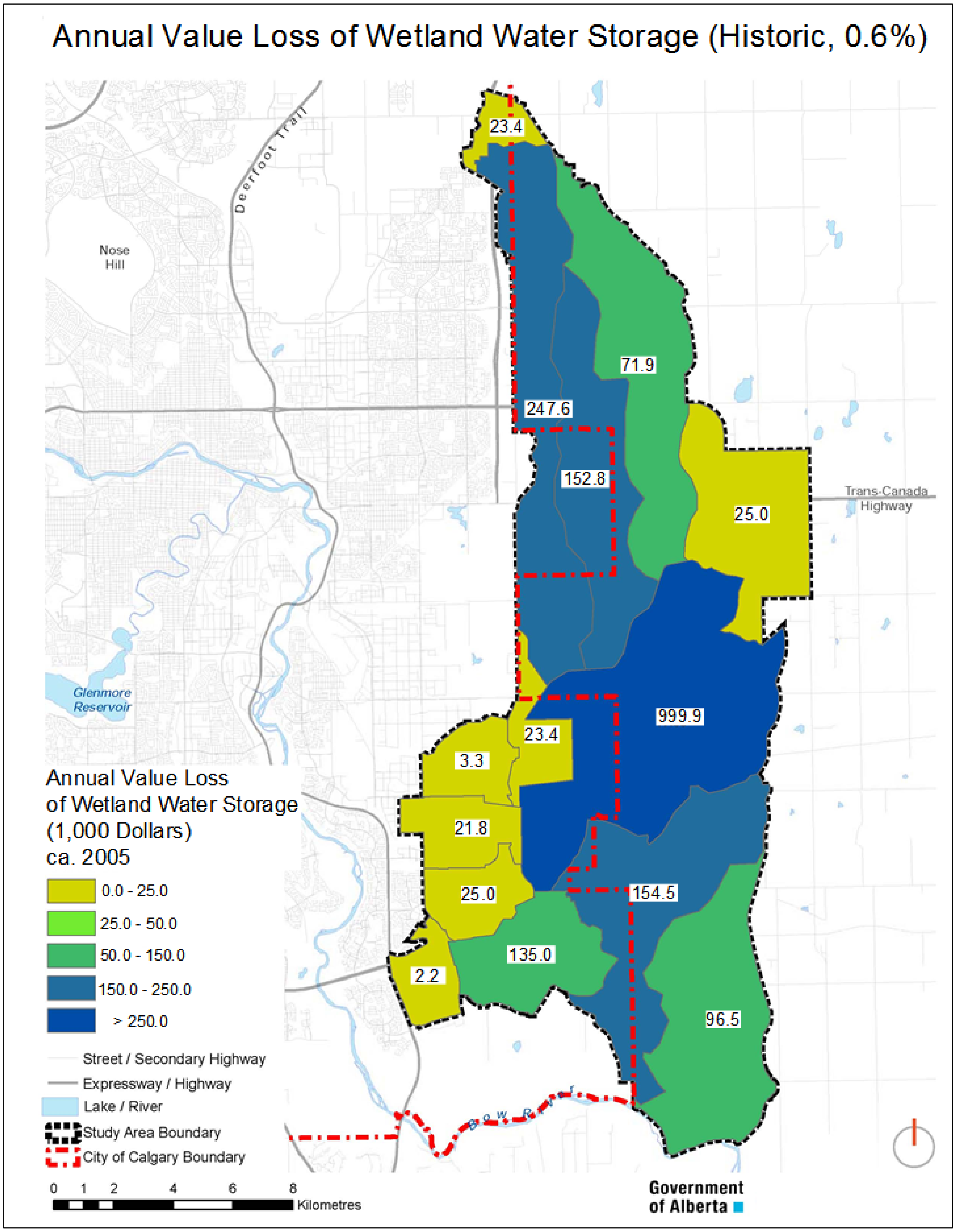
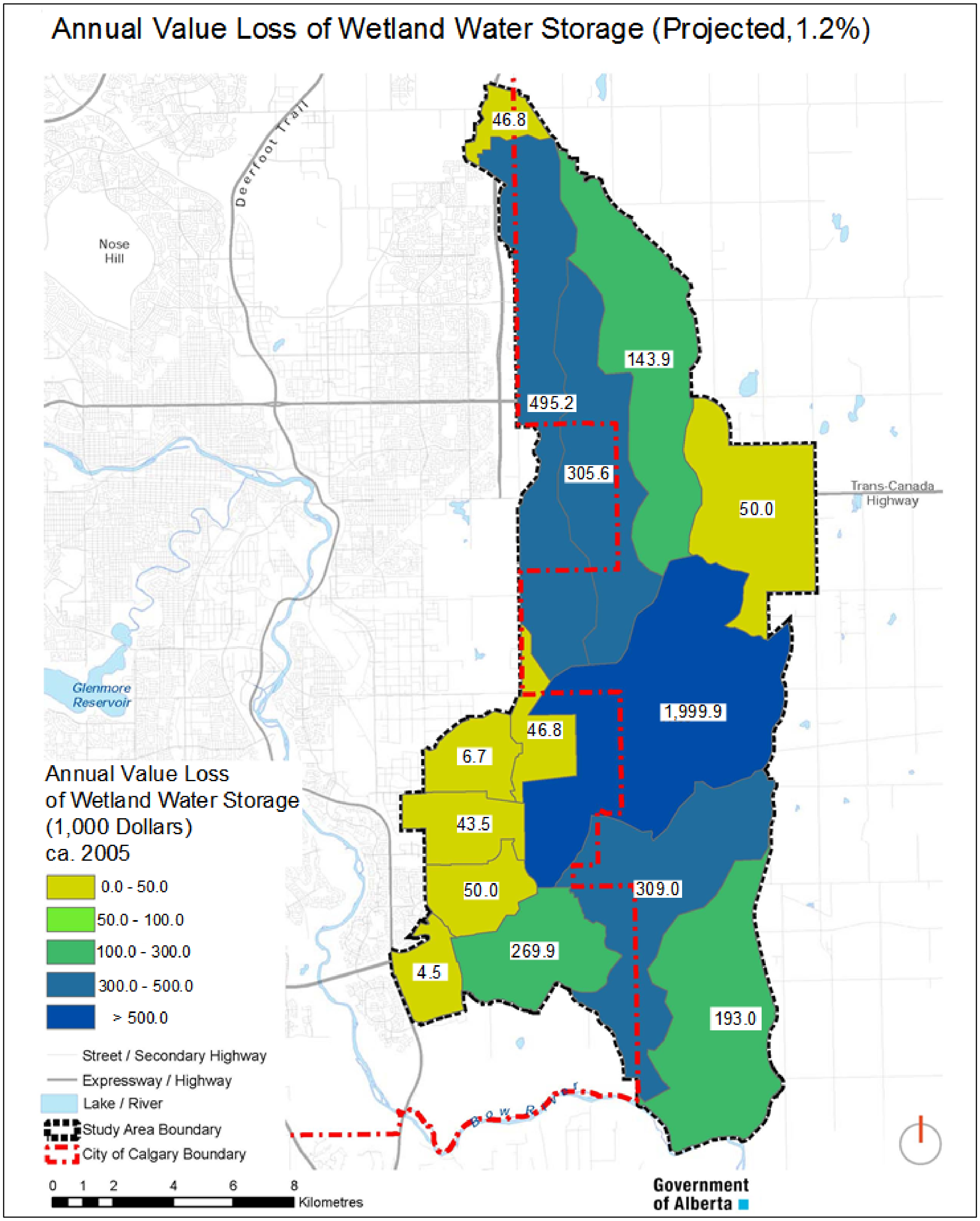


Figure 5.5 Annual Value Loss of Water Storage by W4 Subwatershed (Projected, 1.2%)



5.2 The Value of Water Purification

5.2.1 Introduction

Wetlands are natural filters that improve water quality and help neutralize a number of different contaminants. As runoff and surface water pass through, wetlands remove or transform pollutants through physical, chemical, and biological processes. Wetlands absorb considerable amounts of nitrogen and phosphorus and can serve as a natural waste treatment plant for the excessive amounts of these nutrients from a variety of sources, such as fertilizers from farms, pollutant loading from residential and industrial area. Estimates of nutrient removal vary. Some studies have shown that wetlands can reduce nitrate and phosphorus up to 80 percent and 94 percent respectively (Olewiler, 2004). Scientific studies also report that Canadian wetlands can retain or remove up to 70 percent of the sediments, 90 percent of the bacteria, and a high proportion of the pesticides that enter them. Woltemade (2000) found that two major factors that influenced removal were area of wetland to its catchment size and the retention time of nutrient.

It is important to note that although wetlands are recognized as sinks for nutrients, under certain circumstances wetlands can be a contributing source to receiving water bodies, especially in late winter / early spring before vegetation is growing, dead vegetative material can be flushed out (AECOM, 2011a). In the context of the study area very few wetlands are a contributing source. First, majority of the wetlands have no surface connection to the Bow River, the nearest potential receiving water body. Second the surface connections between wetlands are also limited leading to high potential for water retention time in a wetland. These two factors means that currently limited amount of nutrient is likely entering the Bow River. In the future however, it is expected that as further developments occur greater volumes of runoff generated by these developments will need to be directed to the Bow River. Recently, the local municipalities undertook a study, the Shepard Regional Drainage Plan that assessed the impact of development in the area with respect to runoff and its quality. The goal is to minimize loading to the Bow River which is not currently meeting water quality objective for certain parameters. A plan is being developed by Alberta Environment and Sustainable Resource Development to address nutrient loading along the Bow River reach that includes the Shepard Slough.

Acknowledgement of wetland benefits is evident in the developments occurring in the Shepard Slough area. These developments have modified existing wetlands to manage storm water and nutrient runoff. Agricultural areas are not specifically required to manage storm water and nutrient runoff but management practices are promoted to minimize runoff into water bodies. Ultimately however, runoff interception by wetlands is expected. The City of Calgary also recently completed the Shepard Constructed Wetland that will see storm water runoff from a catchment area of nearly 6,000 hectares of existing and future sources managed and treated before eventual discharge to the Bow River.

In addition to local nutrient management, wetland benefits are often assessed in the context of reduced cost of water treatment downstream because wetlands provide cleaner water source that would have occurred otherwise. However, for the Shepard Slough this value approach is not suitable since downstream water users that are of considerable distance are supplied with water from upstream of the Shepard Slough.

Another value category is the value of receiving environment for a variety of uses. One such use is the waste assimilation benefit provided by the Bow River. Alberta Environment and Sustainable Resource Development has standards that govern conditions under which effluent discharges are permitted. There are a number of discharges downstream of Shepard Slough and the ability to discharge is affected by the condition of the receiving environment. In focusing on this value category it should be noted that existing loadings on the Bow upstream of Shepard Slough are very large relative to expected additional loading from Shepard Slough development as such, incremental effect of loadings from this area are likely not to appreciably change water quality condition on the Bow River. Nonetheless, it is acknowledged that reduced loadings on the Bow are a desired objective. For water quality and filtration valuation, this report focuses on onsite water purification and on the receiving environment condition.

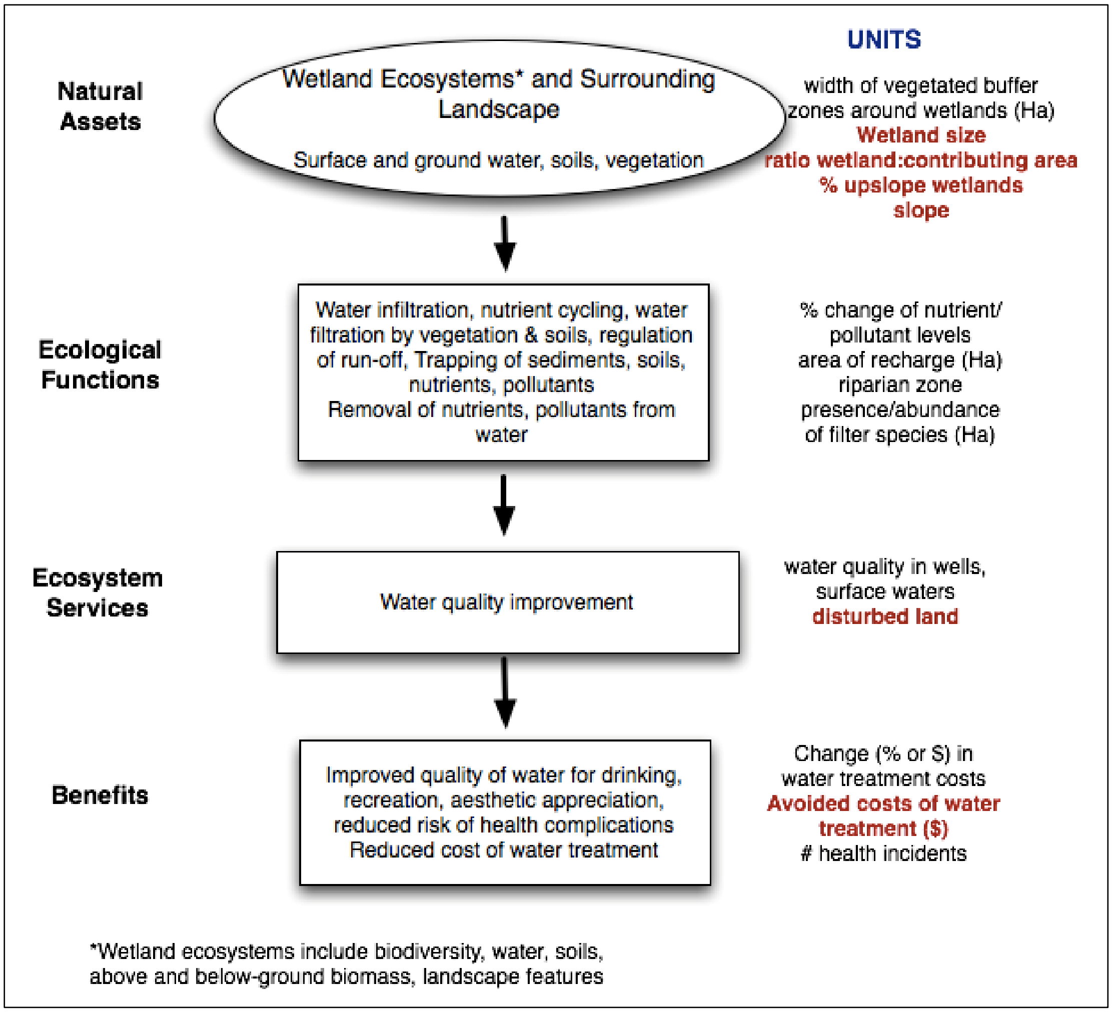
Notwithstanding these two objectives, a major challenge in valuing water quality improvement is that although there is evidence of wetland use for water quality filtration, locally calculated and measured data is unavailable. Local treatment costs of phosphorus and nitrogen (in terms of $/kilogram) was not available at the time of writing this report. Thus, the values derived in the report are estimated from the literature and applied to the study area as appropriate.

5.2.2 Methodology

For both value categories replacement a cost approach was used (Figure 5.6). Constructed wetlands are now used frequently for the treatment of contaminated or nutrient-enriched wastewater. Developments in Shepard Slough are modifying existing wetlands for nutrient management; replacement cost approach calculates the value of constructed wetland if existing wetlands were unavailable for water filtration. For receiving water environment, the replacement cost calculated the cost to treat the water if wetlands were not available.

Also the cost to build conventional water treatment plants with the same capacity of water treatment is explored, in comparison to the cost of constructed wetlands. However, local treatment costs of phosphorus and nitrogen (in terms of $/kilogram) are not available.

Figure 5.6 Ecosystem Services Cascade: Water Purification



5.2.3 Data Collection

Nutrient Management: Amount of expected storm water runoff and nutrient is derived from AECOM (2011a; 2011b) which estimated developments under 'normal' and source control practices. The developments modeled by AECOM (2011a) in the Shepard Regional Drainage Plan were based on current and projected land use designations from local municipalities. AECOM (2011a) estimated that 'normal' development would result in annual runoff of 26 million m^3, 8.7 tonnes of phosphorus, 38 tonnes of nitrogen and 3,700 tonnes of total suspended solids. Source control practices are expected to reduce the runoff to about 16 million m^3, phosphorus to 2.3 tonnes, nitrogen to 15 tonnes, and total suspended solids to about 480 tonnes annually. The total cost of source control practices is estimated at $777 million. Existing wetlands are assumed not to be used to manage the runoff that remains after implementation of source control practices. Rather naturalized channels and constructed wetland are used along the conveyance network prior to discharging to the Bow. These naturalized channels and constructed wetlands are expected to improve water quality. Since local data was not available, literature derived value of nutrient removal was applied to existing wetland area.

Receiving Environment

The receiving environment analysis focuses on the ability of Strathmore, a community located downstream of Shepard Slough to be able to discharge its waste water into the Bow. Strathmore recently completed an upgrade costing about $21 million so that discharges comply and exceed provincial guidelines. This upgrade will allow Strathmore continuous discharge directly into the Bow River. This upgrade is designed to meet the need of population of 30,000; Strathmore's current population is about 12,000.

The local treatment costs of phosphorus and nitrogen (in terms of $/kilogram) are not available. In addition, it is not known exactly how much phosphorus and nitrogen a typical wetland can absorb because amounts depend on the particular type of wetland, its location and plant composition, and the chemical and physical characteristics of soil type. Some estimates from the literature are that wetland plants (duckweed and pennywort) can remove between 116 and 770 kg/ha/yr of phosphorus and 350 to 32,000 kg/ha/yr of nitrogen (Olewiler, 2004). A quasi-natural field of reeds can remove 101 kg/ha/yr of phosphorus and 1,910 kg/ha/yr of nitrogen (Olewiler, 2004). Estimates from a North American database offer the conservative estimates of 80.3 kg/ha/yr for phosphorus and 547.5 kg/ha/yr for nitrogen (Olewiler, 2004). Unfortunately, there is a lack of physical quantifiable information of wetland nutrient absorption at the local or even regional scale. This could be refined if the data gap is addressed in future. Therefore, for water quality and filtration assessment estimates from storm water management (see AECOM 2011a) database have been used in estimating potential nutrients removal capacity of wetlands in our study area. The estimates derived were for storm water ponds located in urban areas with size ranging from 0.4 to 500 hectares.

The degree of impact or alteration of the natural wetland system influences the cost of successful restoration. In Calgary, the cost is $17,500 per ha for restoration at the site of restoration. The restoration costs are considerably less expensive than constructing artificial wetlands of the same size (Scott, 2011). However, most of the historic restoration practices by DU are off-site restorations, which usually take place in rural areas away from urban centers. If restorations occur at the sites of impact, in this case, within the study area, this will substantially inflate the cost of restorations due to much higher costs of land acquisition proximate to the City of Calgary. As a results, the average restoration cost of $17,500 per ha should be considered as the lower bound of estimate as well as the total restoration cost estimate.

Initial construction costs of treatment wetlands are relatively low compared with traditional water treatment systems. Because the wetlands require little maintenance, long-term costs are also quite low. The cost of the constructed wetland is proportional to the number and sizes of treatment cells required. In general, however, it costs $86,450 to $370,500 per ha for constructed treatment wetlands, or about 50 to 90 per cent less than conventional treatment techniques (White, n.d.). AECOM (2011a) estimates the unit cost ($/kg) of Total Suspended Solids (TSS) removal from constructed treatment wetland of $10 to $49 per kg (without consideration of land costs). The research conducted by Kadlec and Knight (1996) on North American treatment wetland operational performance indicated that treatment wetlands removed TSS 31-41 times more than phosphorous on a per unit daily removal basis (kg/ha/d). Thus assuming the per unit removal of TSS is 36 times more that that of P, the unit cost of P removal from constructed wetland is determined to be $360 to $1,764 per kg, by multiplying the unit cost of TSS removal ($10-49 per kg) with the factor 36.

5.2.4 Results and Discussion

Nutrient management benefit was calculated for phosphorus, the nutrient of most concern in the Bow River (Table 5.3). The total wetland area of 2,450 hectares was multiplied by removal rate of 80.3 kg/yr/hectare to derive the total potential uptake of about 197,000 kg annually. Based on the unit cost ($/kg) of phosphorous removal from constructed wetland of $360 to $1,764 per kg, the annual average value ranges from $28,908 to $141,649 per ha. It is thus estimated that the annual water purification benefit of Shepard wetland ranges from about **$71 million** to **$347 million.** Note that this estimate excludes land acquisition cost; these costs are not provided as they tend to be site-specific and no local estimate was available. Nonetheless, in the urban fringes such as our study area land acquisition cost is likely to significantly increase the total cost. Using the most conservative assumption of the cost of constructed treatment wetlands being about 50 per cent less than conventional treatment techniques (White, n.d.), the cost of using conventional treatment techniques is estimated of **$141.6 million** to **$694.1 million.** Furthermore, it is unlikely that all the wetlands would be lost in a single year. Therefore, an annual loss was applied to estimate the annual change in water purification benefits. Using historic (1962 to 2005) annual loss of approximately 0.6 per cent (Badiou, 2011a), this loss was estimated to range from about $425,000 to $2.1 million for replacement of constructed wetlands, and about $850,000 to $4.2 million for replacement of conventional techniques. Assuming doubling of the annual wetland loss, the annual value loss is estimated to range from about $850,000 to about $4 million if using constructed wetlands, and about $1.7 million to $8.3 million if using conventional techniques.

The restoration costs of existing wetlands are calculated at an estimate of **$43 million**[7]. Using historic (1962 to 2005) annual loss of approximately 0.6 per cent and projected annual loss of 1.2 per cent, the restoration cost was estimated at **$257,250** and **$514,500,** respectively. Figure 5.7 shows total value of wetland water purification by W4 subwatershed. The highest values occur in the middle of the study area where large wetland complexes are located.

Table 5.3 Values of Water Purification and Annual Value Loss for the Study Area

Water Treatment Option	Total Value ($)	Annual Value Loss (0.6% annual wetland loss)	Annual Value Loss (1.2% annual wetland loss)
Wetland restoration	$42,875,000	$257,250	$514,500
Constructed wetlands	$70,824,600 - $347,040,540	$424,948 - $2,082,243	$849,895 - $4,164,486
Conventional water treatment techniques	$141,649,200 - $694,081,080	$849,895 - $4,164,486	$1,699,790 - $8,328,973

[7] It may be an underestimate as it only accounts for the cost of off-site restorations which usually occur some distance from urban area (the site of impact). The cost of restoration, should it be done within the study area, would be much higher due to high land acquisition costs proximate to the Calgary area.

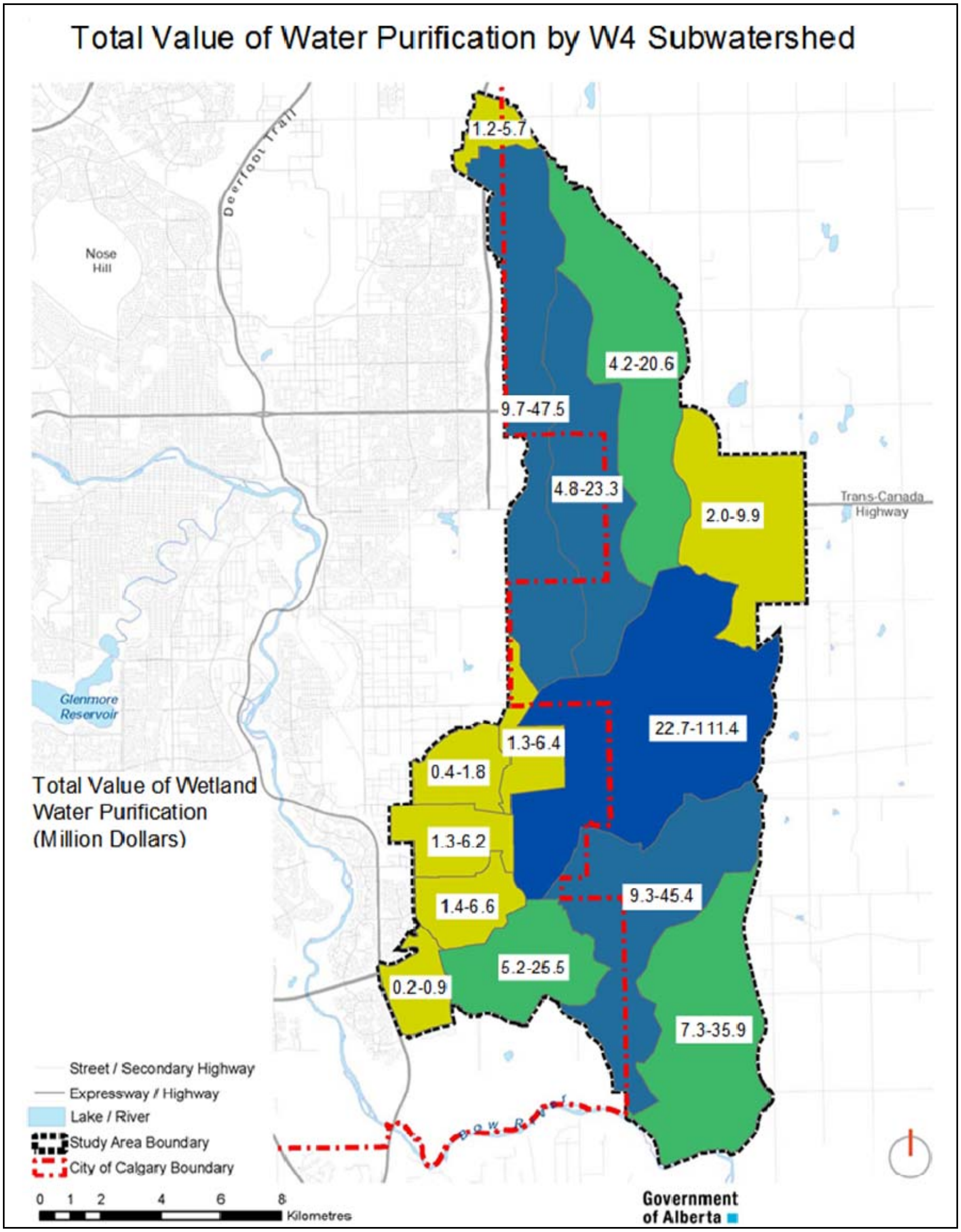


Figure 5.7 Total Values of Wetland Water Purification by W4 Subwatershed

For the receiving environment, focusing on Strathmore specifically, it is not known if the upgrade to a population of 30,000 reflects the stringency to which downstream discharges have to comply to prevent further erosion of water quality in the Bow River. It is possible that higher population capacity is designed with expectation of increased population growth. Over the two of census periods, Strathmore has experienced growth ranging from 10 per cent (1996-2001) to (2001-2006) 32 per cent. Nevertheless, the addition of nutrient upstream of Strathmore could potentially affect its ability to discharge its wastewater. However, the value of this impact is not estimated.

Evaluation of this benefit was limited by the lack of locally relevant data regarding nutrient loadings and uptake by wetlands. Although reasonable care was taken in applying literature derived values, further work to refine and calibrate those values to local context is recommended. Despite this limitation, the results contained in this report provide a 'rule of thumb' estimate regarding the value of water filtration services. It should be noted that water quality improvement and storm water management are co-related objectives. Often wetlands are used for both purposes and estimating separate value for each and aggregating them may potentially double count the benefits. Water quality benefits in the report are likely understated since some filtration benefits of wetlands such as Shepard Constructed Wetland are omitted to avoid double counting. Flood control benefits likely also capture some water purification value.

Estimates of the savings in waste treatment costs provided by nature likely underestimate the value of the wetlands for its water filtration and purification services because they do not reflect society's total willingness to pay for water quality. These water purification services are a small part of the total value of a wetland to the region. There are many other services for which monetary valuation cannot be estimated.

5.3 The Value of Water Supply

5.3.1 Introduction

Wetlands provide valuable services to society including the supply of fresh water, in the form of drinking water for both people and livestock, and in some cases as water for crop irrigation (MEA, 2005). Wetlands act as reservoirs for the watershed. Wetlands release the water they retain (from precipitation, surface water, and ground water) into associated surface water and ground water. Ground water can be adversely affected by activities that alter wetland hydrology (Winter, 1988). In particular, this affect is particularly attributed to ephemeral and temporary wetlands. Wetlands perform several functions in the provision of water supply. Wetlands store water, capturing snow melt and runoff and can function as a recharge/discharge area for groundwater. With population and development pressures leading to the rapid modification of wetlands, valuable hydrological services are being lost, which poses risks to the quality and cost of drinking water and the reliability of water supplies (Postel and Thompson, 2005).

The numerous wetlands collectively in the Shepard Slough are estimated to have total water storage capacity about 36.3 million m^3 (O2 Planning and Design, 2011). This capacity is larger than the total storage capacity of the Glenmore Reservoir which has a capacity of about 22 million m^3. O2 Planning and Design (2011) also noted that although individually smaller wetlands may have small storage capacity, collectively these numerous wetlands can hold as much water as fewer larger ones. Note that total capacity represents the maximum volume of water that could be stored, actual water availability depends on the precipitation. Wetlands are usually full during spring and the volume of water available declines considerably during summer and dry years. O2 Planning and Design (2011) estimated dry time storage to be 14.3 million m^3 based on LiDAR data acquired during late fall.

O2 Planning and Design (2011) reviewed potential users of water supply from wetlands in the study area and found very limited direct users. Water users are supplied either through piped regional water from the Bearspaw and Glenmore reservoirs far upstream from the study area or from groundwater wells in deep sandstone aquifers with little or no connection to surface water sources. There was also no indication that wetlands were being used for irrigation water. There are five water licences that are located within the study area; however, it is not clear if wetlands are source of these waters. The most obvious use of water supply provision of wetlands would be livestock watering and incidental benefits to crops from being in proximity to moisture rich soils.

5.3.2 Methodology

Livestock watering

O2 Planning and Design (2011) conducted field assessment of selected wetlands as part of the Pilot project and found indications of cattle using wetlands. In order to estimate the potential cattle water need the total number of cattle and livestock was calculated. The study area falls within a Soil Landscape of Canada (SLC) defined by Agriculture and Agrifood Canada. The SLC contains information on landscape classification and the type and numbers of animals[8]. However, SLC is much larger unit than the study area so an estimate of the distribution of cattle in the study area was made. This estimate was made by first dividing the animal population of interest by the total land area that could support animals (perennial forage and tame hay, tame pasture and native). This provided an estimated density (animal per hectare) in SLC that accounted specifically for land that could support animal. Second, the amount of land that could support animals was calculated for the study area. The density was then applied to the lands capable of supporting animals to derive the total animals in the study area. Daily water requirements were multiplied by the total number of animals to estimate the total yearly water requirements for livestock (Figure 5.8).

Crops and hay production

O2 Planning and Design (2011) noted that ephemeral and temporary wetlands are often cultivated for crop production. The enhanced soil moisture within these wetlands can enhance crop yields, particularly in dry years. Hay production within wetlands is also common, particularly in the low prairie and wet meadow zones of all wetland types. However, the effects of wetlands on crop and hay production could be mixed. For

[8] Although animal numbers for pigs and chicken are also listed, it is unlikely these animals access wetlands directly. Even if they do, their water need is likely very minor relative to water use by livestock.

example, excessive moisture in spring as well as wetland soils high in clay may work against water availability to actually reduce crop yields in cultivated wetlands.

O2 Planning and Design (2011) mentioned in their report that crop and hay in surrounding upland vegetation may also benefit from shallow groundwater movement out of wetlands into surrounding upland vegetation in a buffered fringe surrounding the wetland (Schroeder and Bauer, 1984; Gilbert et al., 2006). The distance of the active fringe zone where wetlands strongly influence upland water supplies and storage is difficult to determine, and requires more thorough research prior to applying an adequate buffer distance for GIS measurement purposes. In addition to that, we didn't find any further information in our literature review to support further detailed analysis on this component of benefits. O2 Planning and Design (2011) suggested ESRD staff work with Alberta Agriculture staff and ideally producers as well to come up with reasonable and acceptable assumptions. This could be a future direction to work with if quantified benefits need to be calculated.

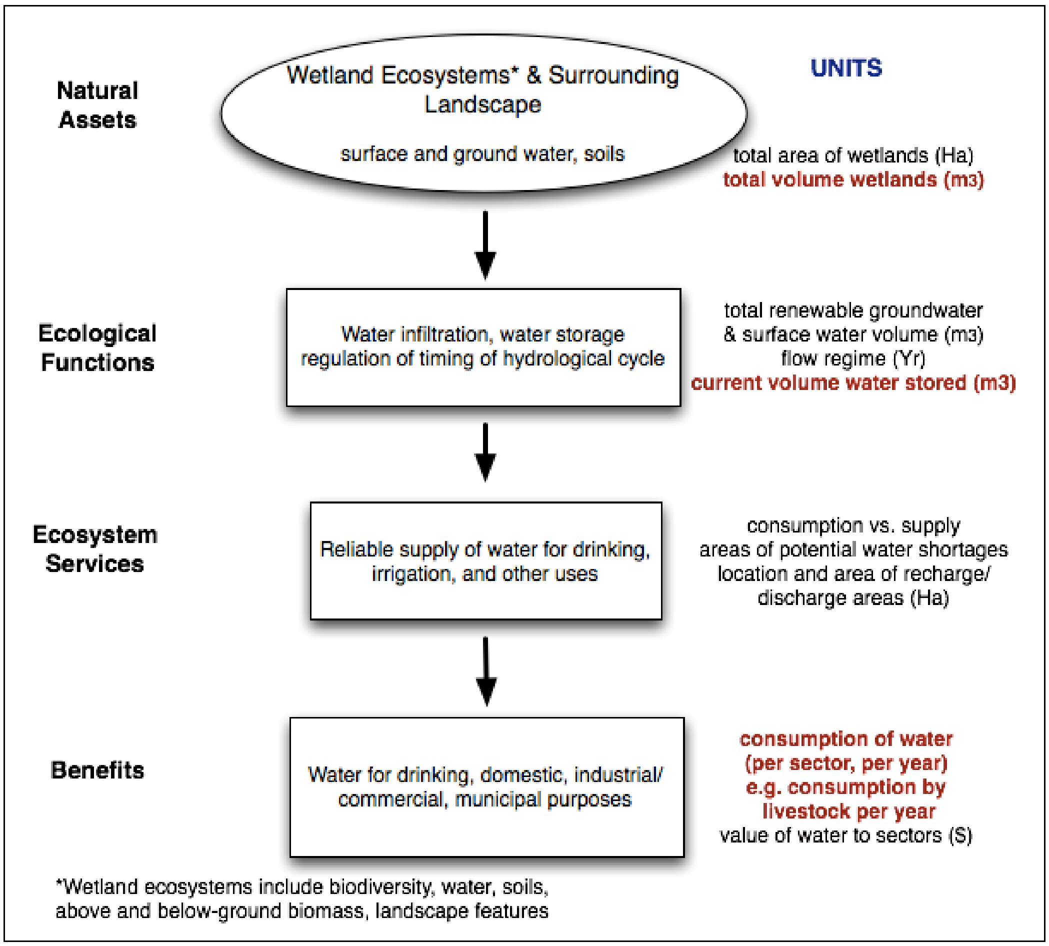


Figure 5.8 Ecosystem Services Cascade: Water Supply

5.3.3 Data Collection

There is no comprehensive livestock inventory available in the study area. Livestock (cattle and horse) data was collected for Soil Landscape of Canada (SLC) unit 798002 for 2006 Census of Agriculture, which represents a larger area including the study area. In this larger area, there are total of 115,624 cattle and 2,157 horses. The land cover that can be used for livestock include perennial forage and tame hay, tame pasture and native grass; these land cover collectively was 69,635 hectares. Within the study area, Grassland Vegetation Inventory (GVI) land classes were analyzed to estimate suitable livestock area. The estimated area was 5,300 ha and included pasture, upland and livestock accessible wetland areas. One limitation of GVI data is that it covers most (90%) but not all of the study area. However, the coverage omission is likely for land classes unsuitable for livestock and thus, overall livestock results are not expected to be affected by the omission. A notable limitation is the assumption that animal population is evenly distributed across livestock supporting land type. If there are intensive livestock operations located in few selected areas in the SLC assuming even distribution will lead to errors in the total numbers of animals estimated for the study area.

Yearly water requirement was obtained from O2 Planning and Design (2011); they used an average value of 38 to 45 L/day or about 15 m^3/year for both cattle and horses.

5.3.4 Results and Discussion

The animal density per hectare was 1.66 and 0.03 for cattle and horses respectively. This density, when multiplied across the area capable of supporting livestock in the study area, resulted in 8,825 cattle and 165 horses. The total water requirement for cattle was estimated to be 132,377 m^3 and 2,469 m^3 for horses. In aggregate, the annual livestock water requirement is estimated to be 134,846 m^3. This volume represents about 0.37 per cent of total water capacity of wetlands and about 0.94 per cent of dry season water availability. Even doubling of animal water demand would represent about 0.74 per cent of total water capacity and two per cent of dry season availability.

As a result of several limitations, monetary values were not calculated. One limitation to water supply assessment is that the scale of analysis is for the whole Shepard Slough, there could be site specific wetland that are used for animal watering for which generalized supply and demand assessment do not hold true. Nonetheless, this analysis does indicate that demand for animal watering relative to water supply is relatively low. O2 Planning and Design (2011) also noted some additional caveats. First, it is unknown what proportion of livestock water requirements are met by wetlands as compared to other sources (groundwater, streams) so the true value will be some fraction of the water need estimated above. Second, livestock use of wetlands is not always desirable and may degrade other ES. Programs such as “Cows and Fish” have been promoting watering system to conserve riparian and wetland health for many years.

5.4 *The Value of Carbon Storage*

5.4.1 Introduction

Climate change concerns have increased the focus on carbon emissions and therefore, have increased decision makers' interest in examining sources for carbon storage/sequestration[9]. Wetlands store carbon in two ways: in the plant biomass and in the soil. This analysis however focused on the soil organic carbon contained in the wetlands because plant biomass can be transient.

While there has been prior studies of carbon stored in the wetlands in parts of Western Canada (Vitt et al., 2000), these studies did not specifically examine the study area. There have also been studies on the economic costs of carbon sequestration (Stavins, 1999; Plantinga et al., 1999; Kindermann et al., 2008) primarily in forests and forest management but there have not been many studies on the economic valuation of carbon storage[10]. In 2000, the Canadian Parks Council conducted a large scale examination using a wide variety of economic methods to develop valuations of carbon sequestration which has provided the basis for our analysis.

5.4.2 Methodology

The Canadian Parks Council's Economic Framework Project, *Carbon Sequestration in Protected Areas of Canada: An Economic Valuation* (Kulshreshtha et al., 2000) conducted a large scale literature review to find value estimations of carbon sequestration in protected areas within Canada. The value of carbon is based on the stock of carbon in the selected areas.

One approach used in the study was the alternative cost of mitigation. Literature was reviewed to determine values for carbon recapture (from various types of plants), alternative technology to decrease carbon emissions, use of renewable fuels and retrofitting to improve energy efficiency. Another approach looked at three papers examining the marginal social opportunity cost method. This method measures the value of reduced economic output such that net carbon emissions remain unchanged due to loss of carbon uptake by natural environment. The quasi-market method looked at suggestions made for market prices for carbon and looked at emissions trading. Replacement cost estimates were found in literature around afforestation and reforestation as well as sustainable forest management. Finally, a substitution cost method was examined. Literature was reviewed in the areas of land cover change (such as tree planting programs, permanent cover program) and geological storage (underground carbon storage, ocean storage) to determine values. Overall, there were a wide variety of values and ranges of potential economic value due to the different methodologies and the variety of studies used to determine value of carbon (Figure 5.9).

[9] Carbon sequestration refers to the flow of carbon, i.e. the uptake of carbon in plants, and soils, etc. for a given time duration. Carbon storage refers to the stock of carbon in soils at a given time..

[10] However, it is reasonable to assume that the value per unit carbon estimates (e.g. $ per tonne C) from the valuation studies on carbon sequestration are applicable to carbon storage.

A carbon storage assessment was conducted by Ducks Unlimited (Badiou, 2011a) to determine the estimated amount of carbon stored in the wetlands in the study area. Using the economic value of carbon sequestration calculated by the Parks report and an estimated value of carbon storage provided by Badiou (2011a), we were able to provide estimates for the economic value of carbon storage in the study area.

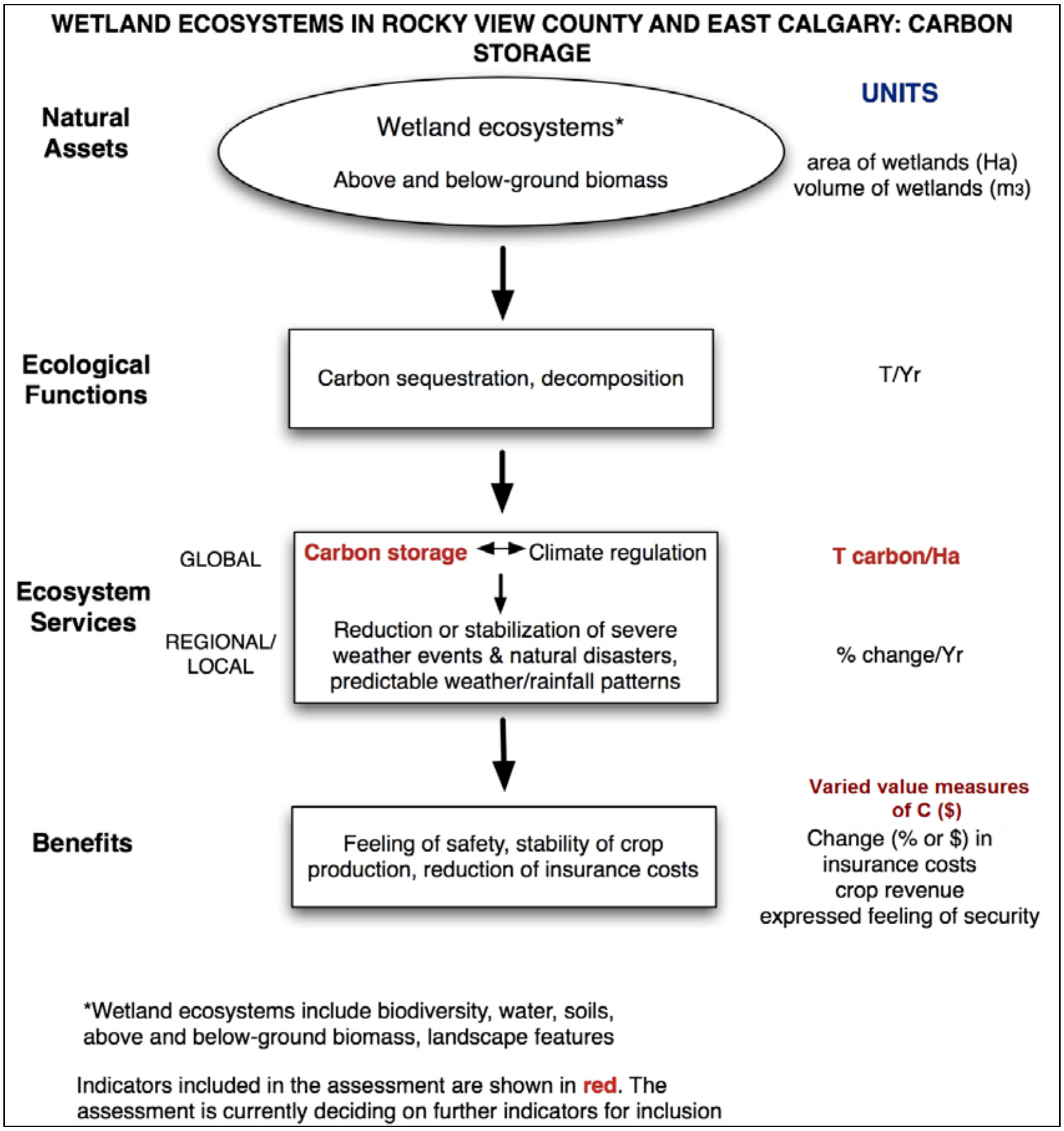


Figure 5.9 Ecosystem Services Cascade: Carbon Storage

5.4.3 Data Collection

Badiou (2011a) assessed the wetland carbon stored in the study area for 2005, the latest data year available for assessment. Wetland inventories to assess carbon storage were based on data collected from a change detection analysis conducted for the Rocky View County. Wetland data was photogrammetrically (stereo) collected from existing true color 1:30,000 frames. The following wetland classes were collected: Wetland (Emergent Vegetation) - Hydrophytic vegetation occupying wetland basin, Wetland (Open Water) - Open Water within an intact wetland basin or Open water zone in dry basin. Wetland (cropped basin) - cultivated depression or wetland margin defined by topography and the presence of water or recent evidence of flooding, includes depressional areas altered by agricultural activities.

Wetland carbon stores were estimated for class 3, 4, and 5 wetlands. Based on previous research conducted on wetlands in the Canadian prairies, Badiou et al. (2011b) observed soil organic carbon concentrations (SOC) of 205 Mg C ha^{-1} in reference wetlands (to a depth of 30 cm). However, not all 205 Mg C ha^{-1} carbon is lost when wetlands are altered, degraded, or lost. Badiou et al. (2011b) estimated a SOC loss of 89 Mg ha^{-1} as the difference in SOC concentration between intact wetlands (205 Mg SOC ha^{-1}) and recently drained wetlands (116 Mg SOC ha^{-1}). This translates into a release of approximately 326 Mg CO_{2eq} for every hectare of wetland loss. This estimate is conservative as it was derived from sites where wetlands were drained but remained in grassland cover. Greater losses are expected in SOC from wetlands that are drained and put into agricultural production or that are excavated and developed.

By applying a SOC pool of 205 Mg for every hectare of class 3-5 wetlands, it yielded an estimate of total wetland SOC 304,276 Mg for the whole study area in 2005. The estimated loss of SOC between 1962 and 2005 is 44,144 Mg. As was the case for wetland area, SOC pools were calculated based wetlands that are greater than 0.5 hectare. In addition, a SOC loss of 89 Mg ha^{-1} was applied in the calculation as a conservative estimate of the amount of carbon re-emitted back to the atmosphere due to wetland loss (specific to class 3-5 wetlands).

5.4.4 Results and Discussion

One finding from the study is that carbon value varies considerably, depending the context and purpose for which valuation is conducted (Table 5.4). By multiplying the stock of carbon with the unit value from Kulshreshtha et al. (2000), a range of economic values were estimated for wetlands in the study area (Table 5.4). The value ranges from a low of **$608,552** (from the lower estimation of replacement cost) to a high of **$299 million** for the marginal social opportunity cost.

Table 5.4 Value of Carbon Storage in Wetlands for the Study Area

Valuation Method	Value of Carbon per tonne ($)	Value of Carbon Storage
Alternative Cost	$15 - 645	$4,564,140 - $196,258,020
Marginal Social Opportunity Cost	$982	$298,799,032
Quasi- Market Method	$15 - 55	$4,564,140 - $16,735,180
Replacement Cost Method	$2 - 104	$608,552 - $31,644,704
Substitute Cost Method	$8 - 375	$2,434,208 - $114,103,500

In Alberta, large emitters have been given three options to reduce the intensity of their greenhouse gas emissions by 12 per cent as required by Alberta's *Climate Change and Emissions Management Amendment Act* and its accompanying Specified Gas Emitters Regulation: improve the energy efficiency of their operations, buy carbon credits in the Alberta-based offset system[11] or pay $15 per tonne of CO_2eq into the Climate Change and Emissions Management Fund for every tonne over their reduction target. Facilities could also choose a combination of the options. If **$15/tonne of CO_{2eq}** (equivalent to $55/tonne of C) is used, the value of carbon storage in the study area would amount to **$16.7 million.**

By applying a SOC loss of 89 Mg ha^{-1} as the amount of carbon re-emitted back to the atmosphere due to wetland loss, it yielded an estimate of total SOC loss 132,076 Mg if all of the wetlands (304,276 ha) were drained. The value of the SOC loss would range from $264,152 - $130 million. Given the $15 per tonne of CO_{2eq}, the loss of value becomes **$7.3 million** (Table 5.5). However, it is unlikely that all the wetlands would be lost in a single year. Badiou (2011a) estimated the historic (1962 to 2005) annual loss of approximately 0.6 per cent, which resulted in 792 Mg of loss in SOC; this annual loss of value was estimated to range from about **$1,585** to **$778,192.** Wetland loss is likely to increase in the future due to growth in developments. Assuming doubling of the annual wetland loss (1.2%), the annual SOC loss became 1,585 Mg and the annual value loss is estimated to range from about **$3,170** to about **$1.6 million.** Under $15 per tonne of CO_{2eq}, the value loss becomes **$44,000 and $87,000** per year, at 0.6 per cent and 1.2 per cent of annual wetland loss, respectively (Table 5.5).

[11] In Alberta, reforestation and sustainable forest management practices are part of legislated requirements, therefore, these activities would not meet additionality for carbon mitigation offset.

Table 5.5 Possible Value Loss of Carbon Storage in Wetlands for the Study Area

Valuation Method	Value of Carbon per tonne ($)	Total value loss of SOC if all wetlands are drained	Annual value loss of SOC (0.6% annual wetland loss)	Annual value loss of SOC (1.2% annual wetland loss)
Alternative Cost	$15 - 645	$1,981,140 - $85,189,020	$11,887 - $511,134	$23,774 - $1,022,268
Marginal Social Opportunity Cost	$982	$129,698,632	$778,192	$1,556,384
Quasi- Market Method	$15 - 55	$1,981,140 - $7,264,180	$11,887 - $43,585	$23,774 - $87,050
Replacement Cost Method	$2 - 104	$264,152 - $13,735904	$1,585 - $82, 415	$3,170 - $1,885,555
Substitute Cost Method	$8 - 375	$1,056,608 - $49,528,500	$6,340 - $297,171	$12,679 - $594,342

However, these estimates are based on pre-existing values due to time constraints. As markets are further developed for carbon trading or more recent studies come out, it may be worthwhile to revisit these calculations.

5.5 The Value of Recreation

5.5.1 Introduction

Wetlands can contain and support a wide variety of plant and animal life. Many species make wetlands their homes, notably many bird species, amphibians, fish and mammals. This provides an opportunity to enjoy several types of recreational activities such as wildlife viewing, hiking, camping, swimming, boating, hunting and fishing. Wildlife viewing and photography are some of the fastest growing recreational activities in Canada (Olewiler, 2004). Attempting to assign valuation for this ecosystem service can be difficult as these recreation activities can be enjoyed without a direct payment. While there have been other economic valuation studies of recreational opportunities in Alberta (McNaughton, 1995), Canada (Boxall and Macnab, 2000) as well as economic valuation studies of recreational activities of coastal wetlands (Farber, 1988; Bergstrom et al., 1990) to date there has been no comprehensive study done to estimate the recreational benefits of wetlands in the Shepard Slough area. However, these previous studies indicate that the economic impacts and net economic benefits associated with wetlands-based recreation may be substantial and that recreational functions provided by wetlands may be important considerations for wetlands policy and management.

The wetlands in Shepard Slough region have gradually been transformed for use as farmland and urban development (BRBC, 2005). One consequence of this transformation has been the loss of wetlands that have provided ES, including recreational opportunities. More recently, recreation has been recognized as an important ES in this area with the recent opening of Ralph Klein Park (RKP), a protected area within the constructed wetlands, which provides habitat for birds, recreational and educational benefits (Keffer, 2011; AECOM, 2011b).

5.5.2 Study Site and Data Collection

The study area is the Shepard Slough region east of Calgary that includes Ralph Klein Park (RKP) and the Chestermere Reservoir. The major beneficiaries of the ES with this area are the City of Calgary, Town of Chestermere, Western Irrigation District members, and rural residents east of Calgary (AECOM, 2011b; BRBC, 2005). The Shepard Project includes RKP as part of the infrastructure and was opened in July 2010 (Thompson, 2011; City of Calgary, 2011d). The park is located within the City of Calgary (Figure 5.10). It provides educational and recreational experiences via onsite education programs, viewing platforms, walking trails, and information sessions (City of Calgary, 2011b,c).

The park has presently one open trail for recreational use, with all planned trails to be opened in the next two years (Thompson, 2011). The primary recreational activities at this park are birding, walking/hiking, and scenic viewing. Birding is the most popular activity accounting for the majority of the park's recreational use (Thompson, 2011). At the time of this study public attendance is low with construction activities continuing at the site (Thompson, 2011). The park is a suitable end point for travel estimates with most visiting Shepard Slough given the park's facilities and location, which is popular with birders (Hart, 2011).

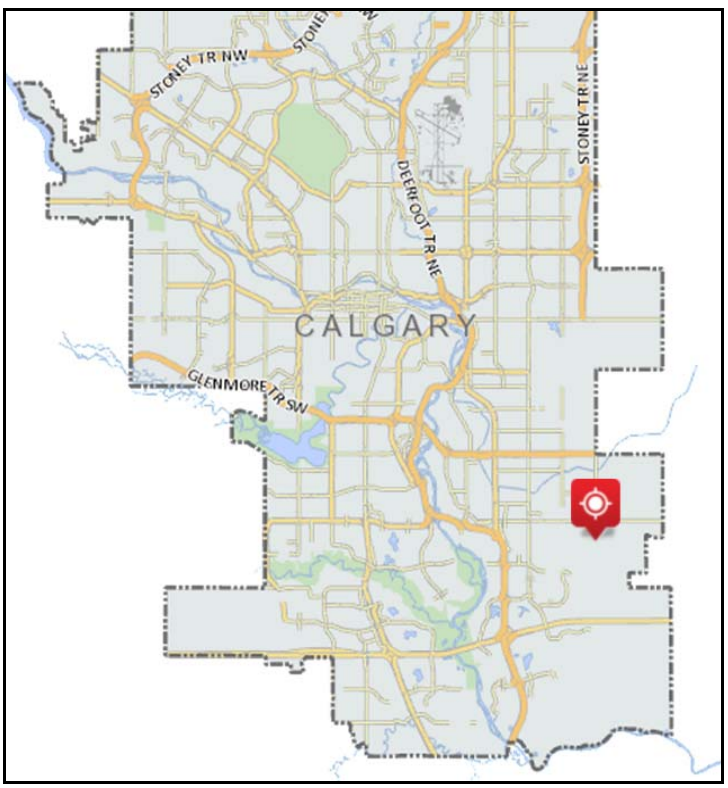


Figure 5.10 Calgary Ralph Klein Park

Data collection consisted of on-site surveys (see *Appendix 3*) of recreation participants at RKP and at Inglewood Bird Sanctuary (IBS) in southeast Calgary. The low attendance rate at RKP necessitated using IBS to collect supplement data collection. Those that attend ISB are likely to attend RKP/Shepard Slough due to the birding opportunities at both sites (Hart, 2011). This makes IBS a good source of survey participants, as those who currently use IBS likely will use RKP in the future. Two versions of the surveys were developed: one for RKP as a stand-alone site, and the second for the Shepard Slough region as a whole. The surveys for Shepard Slough were deployed at IBS, while the RKP specific surveys are used only at the park. Brochures (see *Appendix 4*) outlining the project and background on the ES approach were developed as well as a web address to the online version of the survey. The brochures supplemented the information provided by the survey cover sheet and provided the option of completing a survey online by providing the website address in the brochure. The online survey was developed to encourage participation by having the option of completing a survey at home.

5.5.3 Methodology

There are two main objectives to address the information gap identified above requiring the development of a model to understand recreation behaviour to (Figure 5.11):

a) Estimate the number of people partaking in wetland recreation trips for birding; and

b) Estimate the recreation value of specific wetlands associated with RKP for birding.

The study site was not fully operational at the time of this study and hindered the collection of survey data on recreation activities. As such, information from previous studies and reports were used to establish the base assumptions guiding the estimation model. The assumptions about recreation in RKP/Shepard Slough were:

i. Birding (Bird Watching) is the only recreation activity in RKP/Shepard Slough, and all participants come from Calgary

This assumption is taken from birding being the activity the vast majority of users do at RKP/Shepard Slough (Thompson, 2011). As such, other activities, while having value, are omitted in the analysis. Alberta Tourism, Parks, and Recreation (2008) reported that 14.5 per cent of the survey respondents from the city of Calgary participate in birding. This value is assumed valid of the current population for this work. The removal of rural participants is based on current research work on the Chestermere reservoir that is also within the study area where the vast majority of participants originate from Calgary rendering the rural contribution of value to be low to negligible (Bewer et al., 2011).

ii. Participants in Birding from Calgary are all members of Nature Calgary

The lack of survey data requires assumptions as to where birding participants go. Nature Calgary is a group with a large birding component in their programs (Nature Calgary, 2007). The portion of members that use the Shepard Slough is based on the reported portion of people who are members of Nature Calgary that may use RKP/Shepard Slough as well as other sites in the Calgary area. Nature Calgary (Hart, 2011) reports that 65-80 per cent of their membership use RKP/Shepard Slough for bird watching as well as other sites. The average value of 72.5 per cent was assumed for model calculation.

iii. Participants visit RKP/Shepard Slough once per year using their own vehicle

This assumption is derived from Hvenegaard et al. (1989) that reported birders used their own vehicle 93 per cent of the time and reported 38 per cent visit more than once per year. This leaves the majority in the Hvenegaard et al. (1989) study (62%) visiting once per year, and this is adopted for this study given the lack of survey data.

iv. An Average Distance Travelled is Based on the Distance Between Downtown Calgary and RKP

The estimation of travel costs requires information on how far participants are travelling. The lack of direct data requires using an estimated distance that best captures the average travel distance. A location from downtown Calgary is chosen based on visual inspection of a City of Calgary map. Included in this assumption is that the shortest driving distance between downtown Calgary and the study site.

These assumptions are subject to modification in future studies as more information becomes available from survey collection. The low attendance rate at RKP to date and scant number of surveys completed during the timeframe of this report required using indirect methods of estimating the number of recreation participants. As such, the estimation model of the recreational value of the Shepard Slough will use both the Gravity Model (GM) and the Travel Cost Model (TCM). The GM is used to estimate the potential number of birding participants from the city of Calgary. The GM has an established background in literature for estimating attendance at recreational sites (Leung et al., 2006; Buhyoff et al., 1981; Suanders et al., 1981; McAllister and Klett, 1976; Freund and Wilson, 1974). The GM predicts the level of visits based on population, distance, and other factors like location amenities and services (Sutherland, 1983; Taaffe and Gauthier, 1973). The GM can be adapted to different conditions depending on the scope and context of the study. Saunders et al. (1981) use a modified GM for predicting annual demand for recreation in the Upper Savannah River Basin for the years 1976, 1980, 1990, 2000, and 2010. The low data requirement of Saunders et al.'s (1981) model is a good fit for estimating the number of participants in this study due to the lack of survey data. The GM model used to estimate the number of visitors to Calgary is (Saunders et al., 1981):

$$D_b{}^t{}_C = P_C{}^t \bullet R_b \bullet S_b \qquad (1)$$

Where $D_b{}^t{}_C$ is the number of birding (b) participants (demand) out of the population of Calgary in a given year (t). $P_C{}^t$ is the population of Calgary (C) in 2011 (t), R_b is the participation rate out of the total population in birding, and S_b is the portion of the birding participants (R_b) that will use RKP/Shepard Slough as well as other sites like IBS.

The Travel Cost Model is a revealed preference method used widely in recreation value studies (Ward and Beal, 2000). This method allows for the travel costs of recreation to be equated with benefit and be expressed in monetary terms (Young, 2005; Ward and Beal, 2000). Equation 2 shows the travel cost equation used in this study.

$$RECVAL_{sh} = [p_{os} + (p_v \bullet Distance)] \qquad (2)$$

Where $RECVAL_{sh}$ is the per person utility ($) of recreation at Shepard, p_{os} is the onsite costs of food, equipment, and incidentals, p_v is the per km vehicle operation costs, and Distance is the number of roundtrip kilometres to travel to RKP and back from downtown Calgary. Equipment cost estimates typically use the rental costs if equipment is obtained on-site for a given trip and included in (p_{os}) variable (Parsons, 2003). The equipment costs are negligible and not included for those who own their own equipment and use it at multiple sites over many years (Parsons, 2003).

The estimation model for the value of recreation in Shepard Slough/RKP is calculated by multiplying the number of potential participants from eq. (1) with the estimated individual benefits of birding from eq. (2) to arrive at the total value estimate eq. (3).

$$TOTVAL_{sh} = D_b{}^{2011}{}_C \bullet RECVAL_{sh} = [P_C{}^{2011} \bullet R_b \bullet S_b] \bullet [p_{os} + (p_v \bullet Distance)] \qquad (3)$$

The values used for calculating potential participation numbers are $P_C{}^{2011}$ = 1,090,936 (City of Calgary, 2011e), R_b = 0.145 from assumption (i), an Alberta Tourism, Parks, and Recreation (2008) report that revealed 14.5 per centof the survey respondents from the City of Calgary participate in birding. S_b = 0.725 from assumption (ii). The values used for estimating the individual benefit of birding are p_v = $0.56/km, Distance = 43 km, and p_{os} = $14.20. The value for ($p_v$) is based on the average costs of operating of three categories of vehicle representing the majority on Canadian roads and driving 18,000 km per year (Canadian Automobile Association, 2011). The value for Distance is based on measuring the round trip distance from the EPCOR Centre in downtown Calgary to RKP using the City of Calgary interactive map yielding a result of 43 km (City of Calgary, 2011f). The EPCOR Centre was chosen as the origin due to its central location in downtown Calgary upon visual inspection of a map of the city. The value of (p_{os}) is derived from the portion of the total cost of bird watching day trips reported in Hvenegaard et al. (1989). This value is 26.3 per cent of the daily total of $54 per day for a day trip (Hvenegaard et al., 1989). This yields a value of $14.20 for ($p_{os}$). The cost of time for travelling is taken to be zero for this work as other research has suggested that time costs are not a significant influence of recreation decisions (McKean et al., 2005).

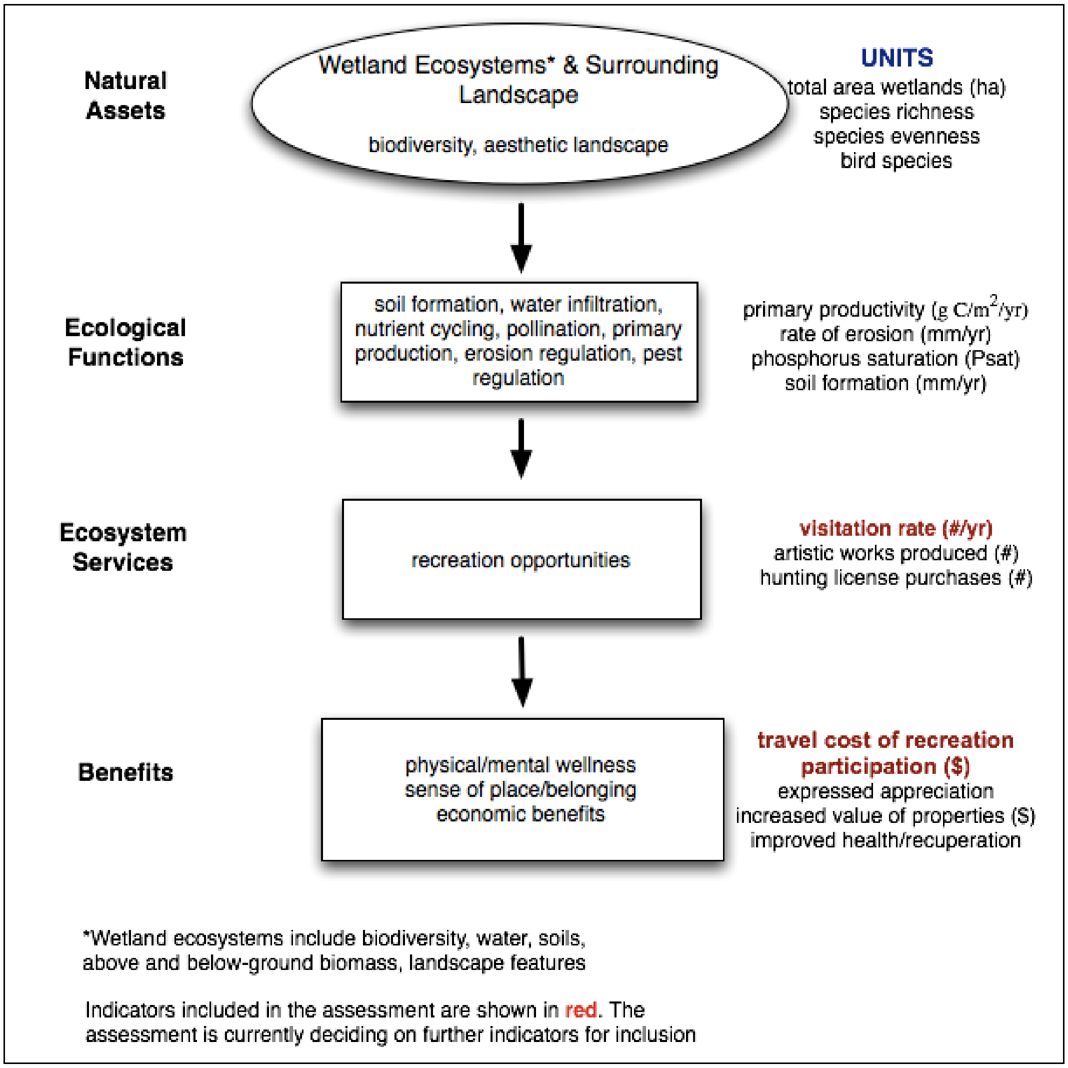


Figure 5.11 Ecosystem Services Cascade: Recreation

5.5.4 Results and Discussion

The annual value for recreation in the Shepard Slough/RKP was estimated at **$4,390,128.** It is based on an estimate of 114,685 participants spending of $38.28 each to go birding at RKP/Shepard Slough once per year. These results show that birding at RKP/Shepard Slough has a significant potential value that warrants attention when developing management plans and policies amid competing uses. As previously noted, once RKP is fully operational, and Calgary residents are fully aware of the available recreation opportunities at RKP, the number of visitors to RKP is expected to be comparable to IBS. The number of visitors to IBS averages around 125,000 annually (Andrews, 2011). The portion of Nature Calgary members that would use IBS and RKP is reported to be 65-80 per cent (Hart, 2011). Using this portion yields 81,250 - 100,000 possible visitors to RKP/Shepard Slough. Accounting for the possibility of others outside Nature Calgary going to both IBS and RKP for birding in the future, the number is likely higher. This is comparable to the estimated number of visitors from the GM portion of the estimation model of 114,000. As such, the estimate from the model is taken to be an acceptable estimate of participation numbers and recreation value for RKP/Shepard Slough wetlands projected into the future.[12]

The sparse number of surveys collected over the study period created challenges requiring the need to use general assumptions based on judgement and values from previous work potentially affecting the precision of the model results. The first limitation is the calculation of percentage of participants from Calgary. The use of the GM with the assumption that all birding participants are members of Nature Calgary and the portion reported by ATPR (2008) survey may not be true of actual participants. This can skew number estimates for participants. The second limitation is the assumption that the only recreation activity is birding. The exclusion of walking and other scenic viewing as valued recreational activities will skew the results of the model below the true recreational value. The third limitation is using a central point that represents the average driving distance for all participants. Assuming that all points in Calgary are equidistant from the centre point, and that all travel times are equal to reach the centre point, is an issue for measuring travel distance and calculating per person travel cost estimates. The city of Calgary, like any other major city, is not uniform in its roadways resulting in travel time differences to get to a location from different parts of the city. This will influence the per person travel cost estimates. The fourth limitation is the use of previous portions from Hvenegaard et al. (1989) to obtain per person onsite costs. There is no way to know if the values from Hvenegaard et al. (1989) are reflective of today's onsite costs, or if portions between cost categories are accurate. Lastly, the assumption of a single trip to RKP/Shepard Slough may not be true of all participants. The few surveys that were collected showed that the number of trips may be as high as 25, with participants travelling 10-30 km to reach the park. However more surveys are needed to make any sound conclusions. It is recommended that the survey collection at RKP, IBS, and online continue beyond this study to build a dataset for future studies.

5.6 The Aesthetic/Amenity Value

5.6.1 Introduction

Urban developments are increasingly incorporating wetland features into their land use planning for two main reasons - amenity and aesthetics, and storm water management. Wetlands are naturally beautiful, abundant in wildlife and a great place to learn about biology and the environment. Wetlands add value to communities and provide many opportunities for recreation. The economics of leaving natural areas in a community is beneficial. For example, Foley (2007) found that residents in Bridlewood Creek (a community in Southwest Calgary) were willing to pay premium to live close to the local community wetland. Storm water management is also an important consideration as urban developments can change the magnitude and volume of runoff that is generated from high proportion of impervious surfaces. Developments utilize wetlands to manage

[12] Since Ralph Klein Park is a new facility its impact on visitation levels at Inglewood Bird Sanctuary is not known. It is possible that Ralph Klein will draw people away from Inglewood, thus recreation value shifts from one location to another. However, because Ralph Klein Park is in the newly developing urban fringes of the city, its presence likely attracts new visitors.

this runoff; sometimes wetlands are newly created while in some cases existing wetlands are modified. These modifications require a *Water Act* approval for wetland disturbance as well as *Environmental Protection and Enhancement Act* approval related to water quality parameters for discharges to a water body.

The housing developments of McKenzie Towne and Copperfield in southeast Calgary are well suited for examining these wetland uses. These developments have incorporated several wetlands in them that serve both as storm water management site as well as providing amenity and aesthetics benefits to residents. These multi-purpose wetlands are likely to occur as developments expand into the case study area. However, because wetland benefits are not directly traded in the markets, market prices for these benefits do not exist. Therefore, estimating these benefits requires non-market valuation approaches. The hedonic pricing is a non-market valuation approach which uses observations on property values to infer values for non-market benefits such as those provided by wetlands. Observing how property value changes as different wetland attributes change, such as proximity to wetlands, provides a way of estimating the benefits of these attributes to property owners (Mahan et al., 2000). This approach has an advantage over others of using observed market prices to build estimates of wetland benefits. Mahan et al. (2000) provide a review of selected hedonic analysis in the literature. Understanding the quantitative estimate of wetland benefits can assist decision making regarding whether wetlands should be preserved or converted to other uses.

5.6.2 Study Site and Data Collection

The study area is two relatively new residential housing communities, McKenzie Towne and Copperfield, located in the southeast portion in the urban fringes of Calgary (Figure 5.12). This area is part of the prairie pothole region which is characterized by numerous wetlands scattered widely on the landscape. The City of Calgary provided tax assessment data as well as the spatial files that contain neighbourhood features for the two communities. The data included sale price and the sale date for arm’s length transaction that occurred from July 1, 2009 to June 30, 2011. A total of 1,223 sales records were included. The tax assessment data contained most but not all the house characteristics typically used in hedonic regression. Specifically the number of bedrooms and bathrooms were missing in the assessment data; however, it was beyond this study’s scope to backfill these missing data.

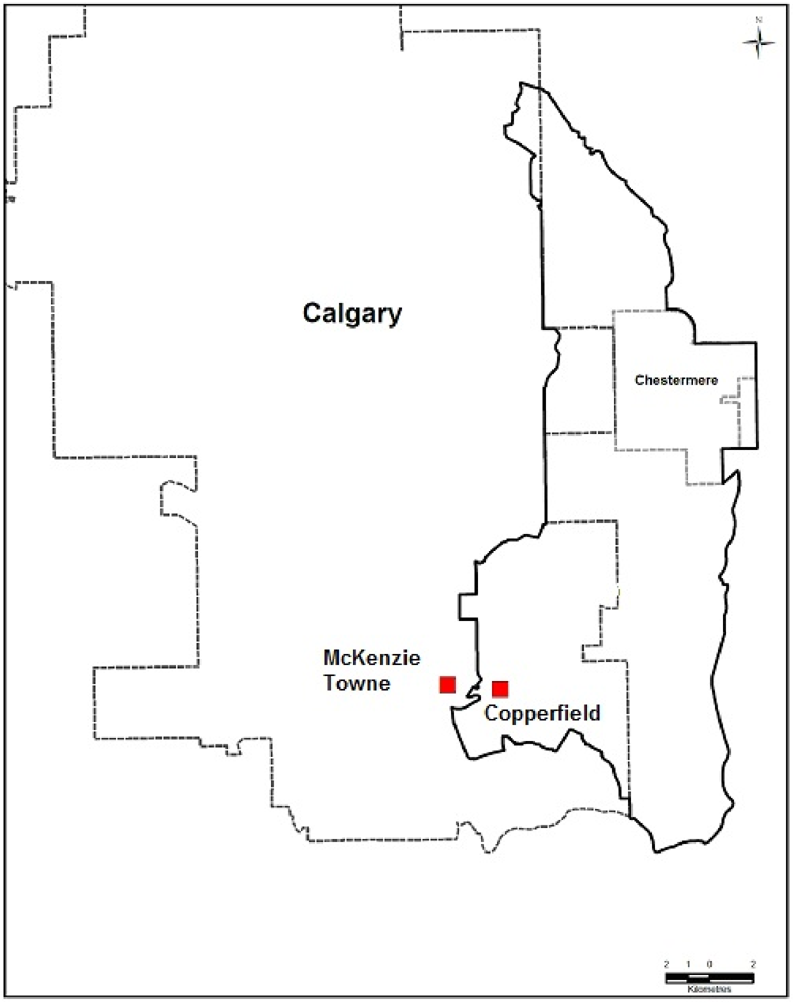


Figure 5.12 Study Communities: McKenzie Towne and Copperfield

The sales price data was checked for unusable observations and missing information. Some observations had much lower sales prices than their assessment values, with differences of up to $200,000; these observations were excluded with the assumption that sale price were only for the lot since this hedonic analysis requires the sale price to include the value of land and its dwelling. Fifteen observations were excluded from the initial dataset. The observations describing the characteristics of the house were also analyzed for missing information. One of the observations had a missing value for building description, rather than exclude that record; a probable value was assigned for the description based on other characteristics of that house. Other than the one missing value no other unusable observations were found.

The dependent variable of the hedonic price function is the sales price of a residence. Actual sales prices are preferred to other forms of data on property values such as assessed, appraised, or census tract estimates because sales come closest to reflecting equilibrium prices (Mahan et al., 2000). For each home sale there is a set of explanatory variables that are used to explain the sales price of the home. The sale prices were adjusted by a price index for Calgary residential housing market to 2010 price level using CMHC (2011)[13]. The explanatory variables consist of structural, neighbourhood and environmental characteristics linked to each property in the data set.

Geographic information system was used to calculate the proximity to environmental and neighbourhood characteristics. The proximity was calculated as the Euclidean distance in metres from the centroid of the property lot to the centroid of the neighbourhood or environmental feature. Distance calculations were made using a raster system where all data were arranged in grid cells.

Some degree of multicollinearity among variables was expected in the data. It came out surprisingly that distance to school was highly correlated with distance to commercial centre because of their proximity in location. Likewise, some other variables were excluded from the model (such as below ground living space, garage area).

In addition, we checked for heteroskedasticity in the data. There is evidence of heteroskedasticity with the resulting Breusch-Pagan test statistic significant at the one per cent level. Because we did not know the exact form of the heteroskedasticity, consistent estimates of the standard errors of the coefficients (and the associated t-statistics) are generated using White's method (Heteroskedastic-Consistent covariance matrix).

The chosen explanatory variables and their definitions are shown in Table 5.6. Descriptive statistics are shown in Table 5.7 (McKenzie Towne) Table 5.8 (Copperfield).

Table 5.6 Variables and Descriptions

Variable Name	***Description***
ADPRICE	House sales prices adjusted to 2010 Canadian dollars (Dependant variable)
	Structural Variables
BLDTYPE	Building descriptions (0=bungalow, 1=bilevel, 2=2 story, 3=3 story, 4=3 level split, 5=4 level split)
FIREPLCE	Number of fireplaces
ALIVSPCE	Above grade living space (square meters)
BASEMENT	Dummy variable for basement development (1 if yes, 0 otherwise)
WLKOUT	Dummy variable for walkout basement (1 if yes, 0 otherwise)
DGARAGE	Dummy variable for garage (1 if yes, 0 otherwise)
LOTSIZE	Area of land (square meters)
AGE	Year house was built subtracted from 2011
	Neighborhood Variables

[13] Some sales actually occurred over January to June 2011 period (12 in McKenzie Towne and 13 in Copperfield), however, the most latest available housing data was for 2010. The housing price index is not expected to change significantly from 2010 as year to year change in house prices have moderated considerably compared to few years ago. The 2011 sales were thus adjusted using the 2010 index.

LOWTRF	Dummy variable for proximity to traffic (1 if yes to Main Road and/or Expressway, 0 otherwise)
COMM	Distance in meters to the commercial center
LNCOMM	Natural log of distance in meters to the commercial center
Wetland Variables	
NRWTLD	Distance in meters to the nearest wetland
LNNRWTLD	Natural log of distance in meters to the nearest wetland
ADJWT[14]	Dummy variable for adjacency to wetlands (1 if yes, 0 otherwise)
Other Environmental Variables	
ENVTRSV	Distance in meters to the environmental reserve
LNENVTRS	Natural log of distance in meters to the environmental reserve

McKenzie Towne

McKenzie Towne has a population of 14,068 and 4,058 residential dwellings in 2009 (City of Calgary, 2011g; City of Calgary 2011h). Approximately 60 per cent of houses in the community are single detached, almost similar to Calgary. The 2005 median household income was $76,353, this compares to $67,238 for Calgary. After the data cleanup 670 observations were reduced to 666 observations that were available for analysis. The average sale price was $380,550 and the median price was $354,760. This neighbourhood has three wetlands (Figure 5.13): wetland 1 (4.16 hectares); wetland 2 (8.25 hectares); and wetland 3 (0.49 hectares). Wetlands 1 and 2 are constructed wetlands which are used for the management of storm water generated in the community. Wetland 3 is a natural wetland that is just south of the municipally designated environmental reserve in the southeast corner of the community.

Table 5.7 Descriptive Statistics of the Variables for McKenzie Towne

Variable Name	**Mean**	**St. Dev**	**Minimum**	**Maximum**
ADPRICE	380,550	109,220	256,000	1,299,200
BLDTYPE	1.94	0.65	0	5
FIREPLCE	0.73	0.52	0	3
ALIVSPCE	144.55	40.44	83.80	305.80
BASEMENT	0.41	0.49	0	1
WLKOUT	0.02	0.14	0	1
DGARAGE	0.56	0.50	0	1
LOTSIZE	368.45	113.00	219.40	1043.60
AGE	6.15	4.30	1	16

[14] Adjacency to wetland is strictly defined as a residence that is directly attached to a wetland without any block (e.g. roads, streets, trails, paths).

LOWTRF	0.04	0.20	0	1
COMM	1842.60	900.23	252.00	5642.50
NRWTLD	687.99	276.54	125.30	1333.10
ENVTRSV	1438.10	832.58	236.35	5394.60
ADJWT	0.01	0.09	0	1

Copperfield

Copperfield has a population of 5,609 with 2,375 residential dwelling in 2009(City of Calgary, 2011g; City of Calgary 2011h).[15] Approximately 85 per cent of houses in the community are single detached, which is higher proportion than in Calgary. The 2005 median household income was $80,407, this compares to $67,238 for Calgary. After the data cleanup 553 observations were reduced to 542 observations that were available for analysis. The average sale price was $383,400 and the median price was $372,600. This neighbourhood has four wetlands (Figure 5.13): 1.33 hectares (Wetland 1); 1.65 hectares (Wetland 2); 0.42 hectares (Wetland 3); and 4.36 hectares (Wetland 4). All the wetlands, except of wetland 3 are used for the management of storm water generated in the community. Wetlands 1, 2 and 4 have been modified for storm water management. Wetland 3 is a natural wetland.

Table 5.8 Descriptive Statistics of the Variables for Copperfield

Variable Name	**Mean**	**St. Dev**	**Minimum**	**Maximum**
ADPRICE	383,840	78,176	257,820	896,680
BLDTYPE	1.99	0.51	0	5
FIREPLCE	0.80	0.49	0	2
ALIVSPCE	160.45	35.98	76.60	256.70
BASEMENT	0.21	0.41	0	1
WLKOUT	0.08	0.26	0	1
DGARAGE	0.66	0.47	0	1
LOTSIZE	374.87	94.77	205.40	954.70
AGE	3.15	2.17	0	10
LOWTRF	0.00	0.04	0	1
COMM	3,136.40	296.67	2,372.80	3,695.30
NRWTLD	309.12	94.41	67.67	621.78
ENVTRSV	1,895.40	584.59	355.10	2,653.90
ADJWT	0.06	0.25	0	1

[15] Note that at the time of this analysis, Copperfield was not fully developed. It is likely that at full development it could be similar size to McKenzie Towne.

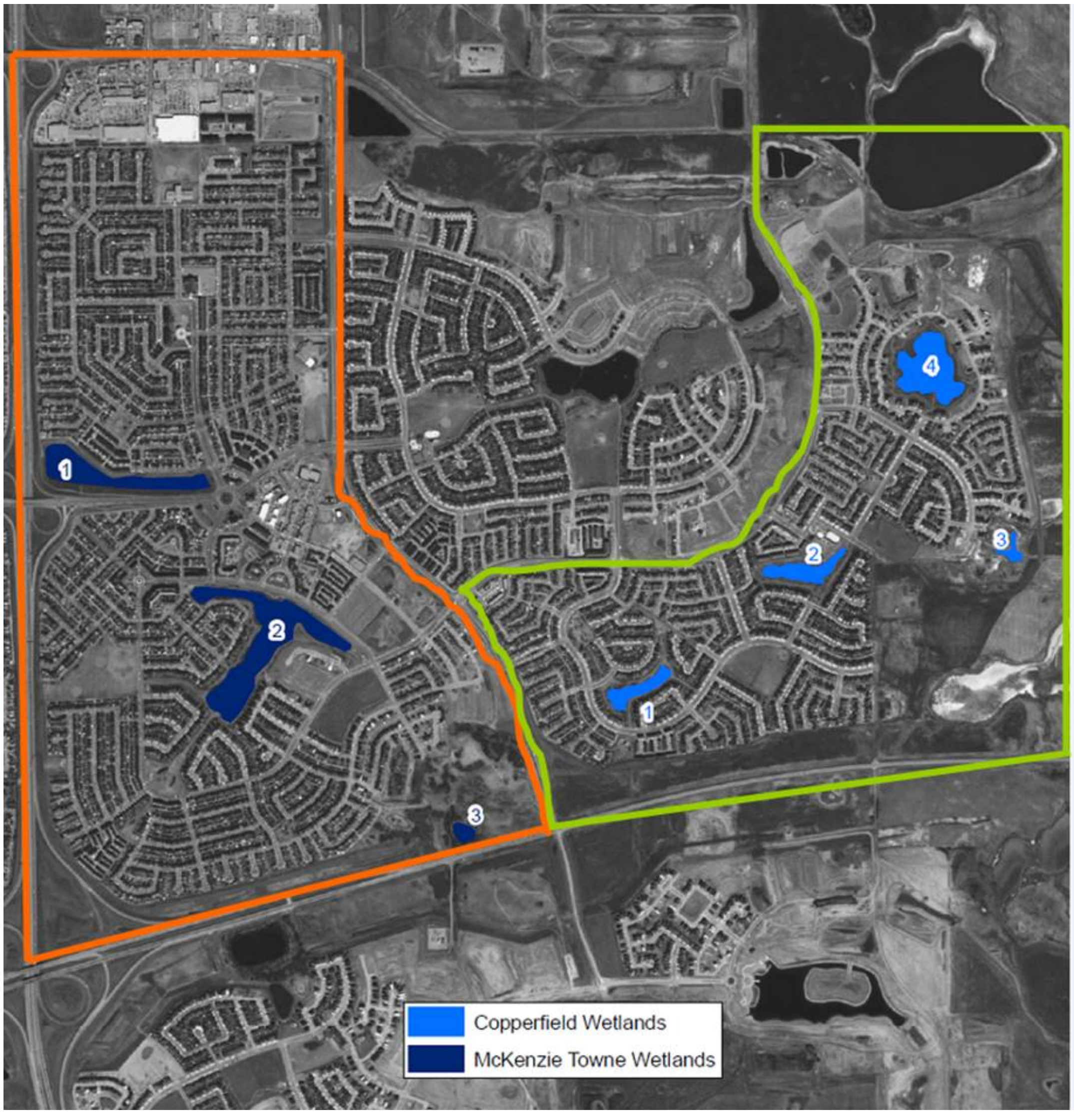


Figure 5.13 The Distribution of Wetlands in McKenzie Towne and Copperfield

5.6.3 Methodology

The hedonic price approach was first proposed by Rosen (1974) and Freeman (1993) provides a useful summary. Essentially, the price of any residence, P_h is a function of property characteristic, S (e.g. house size), neighbourhood characteristics, N (e.g. distance to commercial centre), and environmental characteristics, E (e.g. distance to nearest wetlands) (Equation 1)

$$P_h = P_h(S, N, E) \quad [1]$$

The model assumes that housing market is in equilibrium and that preferences are separable between housing, neighbourhood and environmental characteristics. Under that assumption taking a partial derivative of price with respect to each of the characteristics allows estimation of marginal implicit price of each of the characteristics, including wetland attributes. This marginal implicit price can be applied to the hedonic regression equation to yield value associated with each characteristic.

There are two major issues confronting the econometric specification of Equation 1. The first concerns the selection of appropriate explanatory variables that explain the variation in house prices while the second is the selection of appropriate functional form that best fit the data being analyzed. The former issue is relatively straightforward to address as the literature provides a good guidance on the appropriate variables. The second issue is somewhat more complicated. Although many functional forms have been proposed and used in the literature (e.g. linear, double log, semi-log, exponential and Box-Cox transformations) there is lack of *a priori* knowledge regarding appropriate functional form. Theory only suggests that the first derivative of the hedonic price function with respect to the characteristic in question be positive (negative) if the characteristic is desirable (undesirable). Popular methods to select the functional form include using a linear relationship and altering any variables which are believed *a priori* to be nonlinear and using flexible forms. Mahan (1997), Neupane and Gustavson (2008) provide some literature review for selecting functional form. We tested various functional forms and explanatory variables in the model. Final variable and functional form selection was guided by economic theory and statistical tests. The expected relationship between explanatory and the dependent variable is shown on Table 7.8.

We used least squares regression analysis to estimate the hedonic price function. This function relates sales price to the structural characteristics of the property, neighborhood attributes in which the property is located, and characteristics of nearby wetlands and other environmental characteristics. Equation 1 can be re-written as econometric specification (Equation 2). The model regressed the dependent variable, natural logarithm of house price, against a set of independent variables. Separate models were estimated for each community using the same functional form.

$$\ln P_{hi} = \alpha + \sum_{j=1}^{J} \beta_j S_{ji} + \sum_{k=1}^{K} \psi_k N_{ki} + \sum_{l=1}^{L} \theta_l (\ln E_{li}) + \varepsilon_i \qquad for \quad i = 1,2,...,n \quad [2]$$

where P_{hi} is the sales price of a residence i, S_{ji} is the quantity of the j th structural variable for residence j, N_{ki} is the measure of the k th neighbourhood characteristic, E_{li} is the measure of the l th environmental amenity. α is the constant, β, ψ and θ are estimated model coefficients, *j* denotes the vector of property characteristics for property and ε is the error term. The dependent variable is specified in natural logarithm of the sales prices. The environmental variables are specified as the distance to the nearest wetland in the community and to the nearest environmental reserve. This minimum distance approach was used as the nearest wetland is likely to have the most effect on property value. For variables accounting for distance to some attribute, such as distance to a wetland or distance to the commercial central, we define the distance variable used in the regression equation as the natural log of the distance. It seems reasonable to expect that the effect of distance on property value declines with distance rather than being constant. This specification assumes that wetlands have very localized effects on property value. Dummy (categorical) variables are used to estimate the effects of qualitative characteristics, such as whether a residence has a garage, developed basement and walkout basement.

Table 5.9 Expected Relationship between Dependent and Explanatory Variables

Variable Name	Expected Relationship to Dependent Variable
BLDTYPE	Negative
FIREPLCE	Positive
ALIVSPCE	Positive
BASEMENT	Positive
WLKOUT	Positive
DGARAGE	Positive
LOTSIZE	Positive
AGE	Negative
LOWTRF	Negative
LNCOMM	Positive
LNNRWTLD	Negative
LNENVTRSV	Negative
ADJWT	Positive

For proximity variables such as distance to nearest wetland (LNNRWTLD) and distance to environmental reserve, (LNENVTRSV), a negative (positive) relationship to the dependent variable means residents are willing to pay more (less) to live closer to the feature. That is, the lesser (greater) the distance value, the more (less) the residence is worth. Hedonic studies often include distance to central business district, or downtown, as one of the explanatory variables. This variable is not included because the communities are located next to each other and the travel distance to downtown from each community is expected to be similar; both are far away from Calgary downtown area (over 10 km). The impact of the distance to commercial centre is captured by taking a straight line distance from each property to the community commercial centre located in McKenzie Towne (LNCOMM).

5.6.4 Results and Discussion

Data analysis was performed using the Shazam software (Version 10.0). The results of the analysis are presented in Tables 5.10 and 5.11, for McKenzie Towne and Copperfield, respectively. A pooled model was estimated using the data from both communities. The neighbourhood dummy was significant, which suggested that the two communities are distinct. It confirmed our visual inspection based on Google map and Calgary assessment map). For example, there is a major road dividing the community and wetland features in one community were assumed not to affect the other community. However, the coefficient on the distance to wetland variable was not significant neither was the sign as expected. To examine the unique effects of wetlands and other housing features, two separate models were estimated. Both these models used the same functional form.

Table 5.10 Estimation Results of the Hedonic Price Function for McKenzie Towne

Variable	Coefficient	Standard Error	t-Statistic	p-Value
Structural Variables				
CONSTANT	12.305**	0.126	97.530	0.000
BLDTYPE	-0.010	0.009	-1.121	0.263
FIREPLCE	-0.013	0.008	-1.692	0.091
ALIVSPCE	0.003**	0.000	13.220	0.000
BASEMENT	0.074**	0.009	8.601	0.000
WLKOUT	0.099**	0.028	3.518	0.000
DGARAGE	0.082**	0.007	11.140	0.000
LOTSIZE	0.0005**	0.000	5.847	0.000
AGE	-0.005	0.003	-1.931	0.054
Neighborhood Variables				
LOWTRF	-0.031*	0.012	-2.531	0.012
LNCOMM	0.009	0.009	1.011	0.312
Wetland Variables				
LNNRWTLD	-0.049**	0.017	-2.915	0.004
ADJWT	0.300**	0.080	3.736	0.000
Other Environmental Variables				
LNENVTRS	0.019	0.016	1.183	0.237
Adjusted R^2	0.8585			

Note: One asterisk denotes significance at the 0.05 level and two asterisks denote significance at the 0.01 level. The sample size was 666.

For McKenzie Towne, most of the structural and neighbourhood variables are statistically significant at either the 0.01 or 0.05 level. Coefficient signs are generally as expected; the only exception is the number of fireplaces (FIREPLCE) but it’s not statistically significant. A walkout basement is statistically significant and contributes to the price of the residence by 1.1 per cent. Evaluated at the mean house value ($380,550), the marginal implicit price of walkout basement was estimated to be $4,200. Proximity to traffic has significant impact on house value lowering its price by $3,688 at the mean house value. The distance away from the commercial zone by additional 10 metres increases property values by $20 at the mean house value and an initial distance of 1,842 metres. This reflects the congestion and noise associated with commercial areas, more strongly than the easy access and convenience to shopping.

There is clearly a relationship between property value and distance/adjacency to wetlands. All of the coefficients on the wetland variables (LNNRWTLD, ADJWT) are of the predicted sign and are highly significant. If a property is adjacent to a wetland, the value of the house was estimated to increase by $5,136. Decreasing the distance to the nearest wetland increases house values. The marginal implicit price of decreasing the distance to the nearest wetland by 10 metres, evaluated at the mean house value and an initial distance of 688 metres yields a $271 increase in house value. This is also demonstrated by the relationship between the predicted housing prices and distance to wetlands (see Figure 5.14). The downward relationship shows that when located further from wetlands, the price of a residence decreases at a decreasing rate, approaching asymptotically constant level. This confirms our expectation that wetlands have positive but localized effects on property value.

The coefficient of other environmental variable (LNENVTRS) has an unexpected sign and is insignificant. One explanation is that the municipal designated environmental reserve is located in the southeast boundary of the community, bounded by Marquis of Lorne TR SE in the south and 52 ST SE in the east. This area is close to high traffic and may lessen people's desire to live close by. Also forest and shrub area is not as open and visual views as those wetlands in terms of providing amenities such as open space and opportunities to view wildlife and waterfowl.

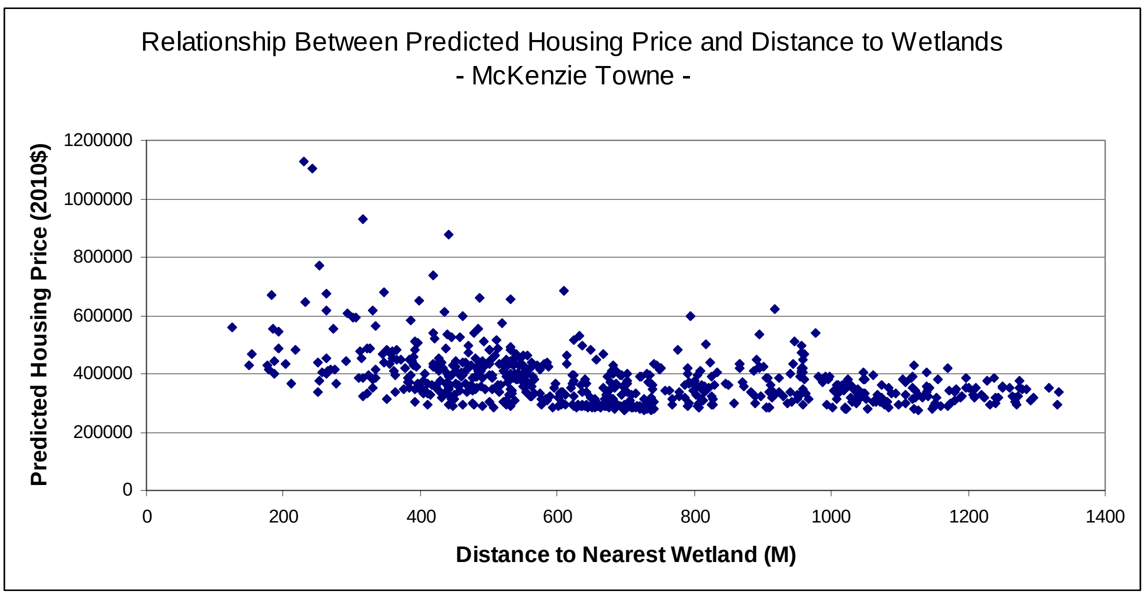


Figure 5.14 The Relationship between Housing Price and Distance to Nearest Wetland (McKenzie Towne)

Figure 5.14 shows that the price of a residence decreases at a decreasing rate, approaching asymptotically constant level further away from wetlands. This confirms our expectation that wetlands have localized effects on property value.

Table 5.11 Estimation Results of the Hedonic Price Function for Copperfield

Variable	Coefficient	Standard Error	t-Statistic	p-Value
Structural Variables				
CONSTANT	11.344**	0.294	38.650	0.000
BLDTYPE	-0.015*	0.006	-2.467	0.014
FIREPLCE	0.043**	0.007	5.854	0.000
ALIVSPCE	0.003**	0.000	16.430	0.000
BASEMENT	0.068**	0.009	7.428	0.000
WLKOUT	0.078**	0.015	5.100	0.000
DGARAGE	0.052**	0.010	5.274	0.000
LOTSIZE	0.0003**	0.000	7.162	0.000
AGE	0.004	0.004	1.017	0.310
Neighborhood Variables				
LOWTRF	0.047**	0.014	3.298	0.001
LNCOMM	0.044	0.038	1.149	0.251
Wetland Variables				
LNNRWTLD	0.062**	0.013	4.825	0.000
ADJWT	0.134**	0.019	7.129	0.000
Other Environmental Variables				
LNENVTRS	0.013	0.022	0.602	0.548
Adjusted R^2	0.8710			

Note: One asterisk denotes significance at the 0.05 level and two asterisks denote significance at the 0.01 level. The sample size was 549.

For Copperfield, most of the structural and neighbourhood variables are also statistically significant at the 0.01 level. Coefficient signs are generally as expected; the exceptions are the years the house was built (AGE), and proximity to main traffic (LOWTRF). A walkout basement is statistically significant and contributes 1.1 per cent to the price of the residence. Evaluated at the mean house value ($383,840), the marginal implicit price of walkout basement was estimated to be $4,309. The distance away from the commercial zone by additional 10 metres increases property values by $54 at the mean house value and an initial distance of 3,136 metres. This reflects the congestion and noise associated with commercial areas, more strongly than the easy access and convenience to shopping.

The relationship between property value and distance/adjacency to wetlands is mixed. All of the coefficients on the wetland variables (LNNRWTLD, ADJWT) are statistically significant at the 0.01 level. The adjacency to wetlands (ADJWT) has the predicted sign. Adjacency to wetland increases property value by $4,390, evaluated at the mean house value. However, the effect of distance from wetland on property value was not as expected. The positive sign of LNNRWTLD implies that the house value increases when further away from a wetland yet the predicted relationship shows a general downward trend between predicted house value and distance from a wetland (Figure 5.15). However, the model estimates did not show this relationship. One possible explanation for this discrepancy is that Copperfield has a greater numbers of wetlands located closer to residences than in McKenzie Towne. For example, the maximum distance to the nearest wetland is 621 meters in Copperfield, which is about half of that in McKenzie Towne. With most of properties (82%) located within the distance of 200-450 meters from nearest wetlands, there is lack of variability to demonstrate this relationship in the model. In addition, we did not have data to include wetland attributes like visual views that may affect property value. We also did not investigate potential confounding interaction effects between proximity to wetlands and higher density housing. It is possible that proximity to higher density housing has greater effect on property prices than proximity to wetlands. City of Calgary's assessment map inspection of the Copperfield community confirmed presence of higher density housing, however, our data included only single family residential dwelling so the potential effect of higher density housing was not estimated. Wetland size was found to be insignificant and model was robust to the size variable exclusion.

The coefficient on the other environmental variable (LNENVTRS) has an unexpected sign but is insignificant. One explanation is that the environmental reserve is located in neighbouring community (McKenzie Towne) and that reserve is close to a high traffic area which is generally not preferred by people.

It shows that, in Figure 5.15, the price of a residence decreases at a decreasing rate, approaching asymptotically constant level when further away from wetlands. This confirms our expectation that wetlands have localized effects on property value.

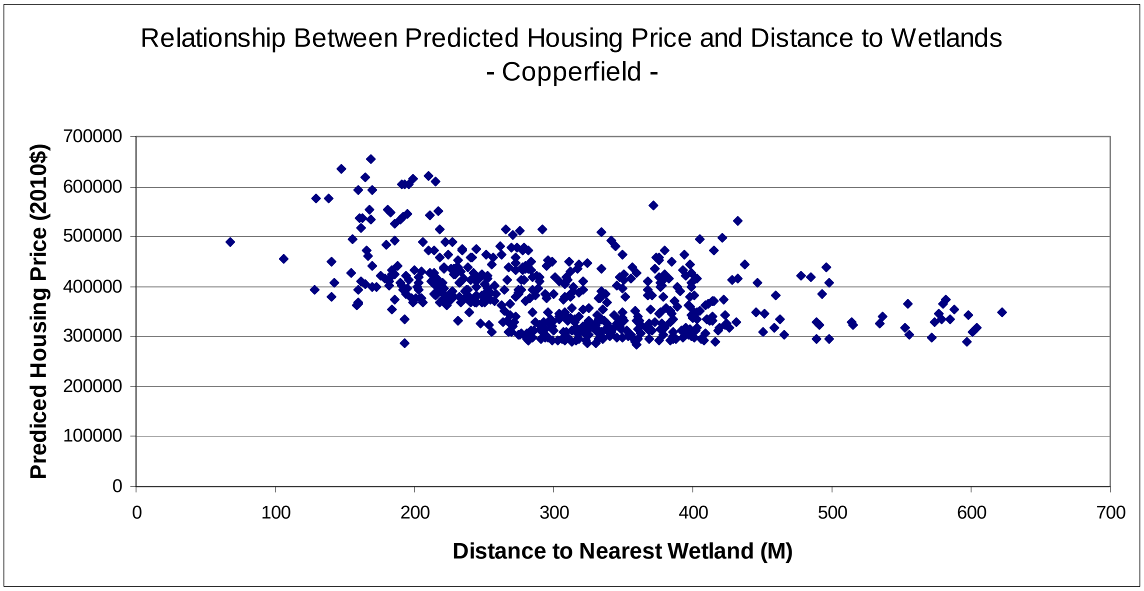


Figure 5.15 The Relationship between Housing Price and Distance to Nearest Wetland (Copperfield)

Table 5.12 summarizes the marginal effects of different house features on the housing prices for two communities. Each of these reported marginal implicit prices is calculated at the mean distance and mean house price using the estimated coefficients reported in Tables 5.10 and 5.11. The distance parameter estimates are with reference to a residence location 1 meter closer to the associated feature (the commercial zone, the nearest wetland and the environmental reserve).

Table 5.12 Marginal Effects of Selected Housing Features on Property Values

Housing Feature	Marginal Effects at Means			
	McKenzie Towne		Copperfield	
	Marginal Implicit Price[16] ($)	Change in Housing Price (%)	Marginal Implicit Price ($)	Change in Housing Price (%)
Above grade living space (square meters)	$1,152	0.303%	$1,152	0.300%
Developed basement	$4,098	1.077%	$4,108	1.070%
Walkout basement	$4,201	1.104%	$4,149	1.081%
Garage	$4,129	1.085%	$4,042	1.053%
Lot size (square meters)	$176	0.046%	$129	0.034%
Proximity to main traffic	-$3,688	0.969%	--[17]	--
Distance to commercial zone (meters)	$2.0	0.005%	$5.4	0.014%
Distance to nearest wetland (meters)	-$27.1	-0.071%	--[17]	--
Distance to environmental reserve (meters)	$5.0	0.013%	$2.7	0.007%
Adjacency to wetlands	$5,136	1.350%	$4,391	1.144%

Wetland Effects on Aggregate House Value

Two components, the value of adjacency (located next to a wetland) and the value of proximity (distance from the wetland) were assessed to examine the effect on aggregate house value. Being adjacent to a wetland has a significant positive impact on house value. For McKenzie Towne, for a house at an average value ($380,550),

[16] The model includes natural log, linear and dummy variables, each of which require specific procedures for determining marginal implicit prices; these prices are calculated at mean values. For the natural log variables, such as distance to nearest wetland, the marginal implicit price is calculated by the wetland distance coefficient times price divided by distance. Take McKenzie Towne for instance, using the mean house price and the mean distance to nearest wetland, one additional metre away from the nearest wetland would result in loss of value by $27, *ceteris paribus(* -.049*($380,550/687.99) = -$27). For the linear variables, such as lot size, the marginal implicit price is calculated as price times the coefficient (.0005 * $380,550 = $176). For dummy variables, such as adjacency to wetland, the exponent of the coefficient is the % change in price from adding the feature. For example, if a residence is adjacent to a wetland, the housing price would increase by EXP(0.300) = 1.35%, or $5,136 at the mean house value.

[17] The marginal implicit prices of proximity to main traffic and distance to wetlands are not calculated here because of the unexpected signs. The possible explanation is discussed in the results.

being adjacent to a wetland increases the housing price by **$5,136**. For the five houses transacted in past two years, it yielded **$65,240.** However, there are many other properties that are adjacent but for which sales data is not available. Using the assessment values as a proxy for sales data, the marginal implicit price of adjacency for 35 properties was estimated **$341,183.** For Copperfield, being adjacent to a wetland increases the housing price by **$4,391**for a house at an average value ($383,840). For 35 houses transacted in past two years, this became **$222,074.** Likewise, the marginal implicit price of adjacency for 152 properties yielded **$844,796** using the assessment values as a proxy. It should be noted that because these neighbourhoods are still developing, with residential lots still available adjacent to a wetland, the estimated aggregate adjacency value is likely an underestimate. One approach could be to apply average value of existing adjacent properties to remaining empty residential lots; the marginal implicit price could then be multiplied by all existing and potential house values.

Proximity also has an effect on house value and this effect has a distance gradient. Prices for houses located further away are less affected than houses located nearer to a wetland (Figures 5.13 and 5.14). For McKenzie Towne, it is assumed that beyond the 700 metres, wetlands have little effect on house values. Holding all the other house features equal to their initial setting, prices for each of the 390 properties from the sales dataset were estimated using the model if they were relocated beyond 700 metres from wetlands. The differences in prices were then calculated for each property and aggregated to represent the total value decrease, amounting to **2.7 million** (**1.8%** decrease). The value decrease became **$16.7 million** if all existing 2,120 properties were considered, representing **1.9** per cent decrease in house value. As noted previously these values are likely an underestimate as we only included fully developed properties. Similar value estimates were not conducted for Copperfield because the sign on the wetland distance variable was not as expected. There are several wetlands and it is likely that all the properties are affected by these wetlands in some way. The model was not able to distinguish the properties with and without impact from wetlands.

One limitation to hedonic price method is that it measures a subset of total benefits wetlands provide. In this study hedonic analysis measured only the amenity value of proximity to wetlands perceived by owner-occupied, single family residence purchasers. Thus, it measures a subset of the total value provided by wetlands.

5.7 Values of Other Ecosystem Services

5.7.1 Educational and Scientific Opportunities

5.7.1.1 Introduction

In addition to local flood protection, water purification and other services within the area, wetlands also provide other important ES that reach beyond the region. The larger South Saskatchewan Region, including the study area, is now home to the largest number of species at risk in Alberta (e.g., Piping Plovers in the sub-basin) (Profile of the South Saskatchewan Region, 2009). The ecological and biological features of wetlands provide a variety of opportunities for people to explore nature. Local and provincial and some international visitors seek out wetlands for educational and research opportunities.

Educational and research opportunities refer to the use of natural areas for formal and informal educational and research enhancement. Natural ecosystems (including wetlands) provide a variety of opportunities for nature study, environmental education (e.g. through excursions) and function as 'field laboratories' for scientific research (de Groot et al., 2002).

There are dozens of provincial and local nature clubs that conduct nature related activities (e.g. birding, hiking) based on wetlands and other natural areas, such as *Nature Alberta* (http://naturealberta.ca/), *Nature Calgary* (http://www.naturecalgary.com), *Calgary Bird Banding Society* (http://www.calgarybirdbandingsociety.org). Part of missions for these nature clubs is "*encouraging the appreciation, observation, study, conservation and protection of all components of the natural world*", with the objectives "*to provide publications and educational opportunities*" and "*to promote the collection of natural history observations for statistical and educational purposes*" (from *Nature Calgary* Website). The Shepard area is recognized as a significant birding area but has increasingly been built up, which leads to fewer birding opportunities in that area[18]. However, many of Nature Calgary birding members visit this area regularly and with the opening of the Ralph Klein Park (RKP) visits to the area are expected to increase multifold (Hart, 2011).

RKP is the Calgary's newest regional park featuring a constructed wetland that uses natural vegetation to treat stormwater before it is discharged into the Bow River[19]. With an on-site Environmental Education and Ethics Centre, it provides educational and interpretive programs to visitors and serves as a scientific benchmark for research into natural processes and human derived change. Once construction is complete, this state of the art facility will deliver innovative environmental education programs and services to Calgary citizens with emphasis on promoting sustainability and stewardship for a healthy future for the city. The facility will serve as the hub for the park and support the outdoor setting through learning gardens, weather stations, wetland study stations and viewing areas, outdoor amphitheatre, and picnic areas.

5.7.1.2 Methodology

The potential indicators used to measure the educational and research services could be presence or area of sites or species of scientific or educational value (Ash et al., 2010). Number of school visits is used as a possible proxy (Figure 5.16).

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[18] Nature Calgary website: http://birdcomp.fanweb.ca/locations_Langdon.html accessed on Aug. 30, 2011.
[19] City of Calgary Website: http://www.calgary.ca/CSPS/Parks/Pages/Locations/SE-parks/Ralph-Klein-Park.aspx accessed on Aug.29, 2011.

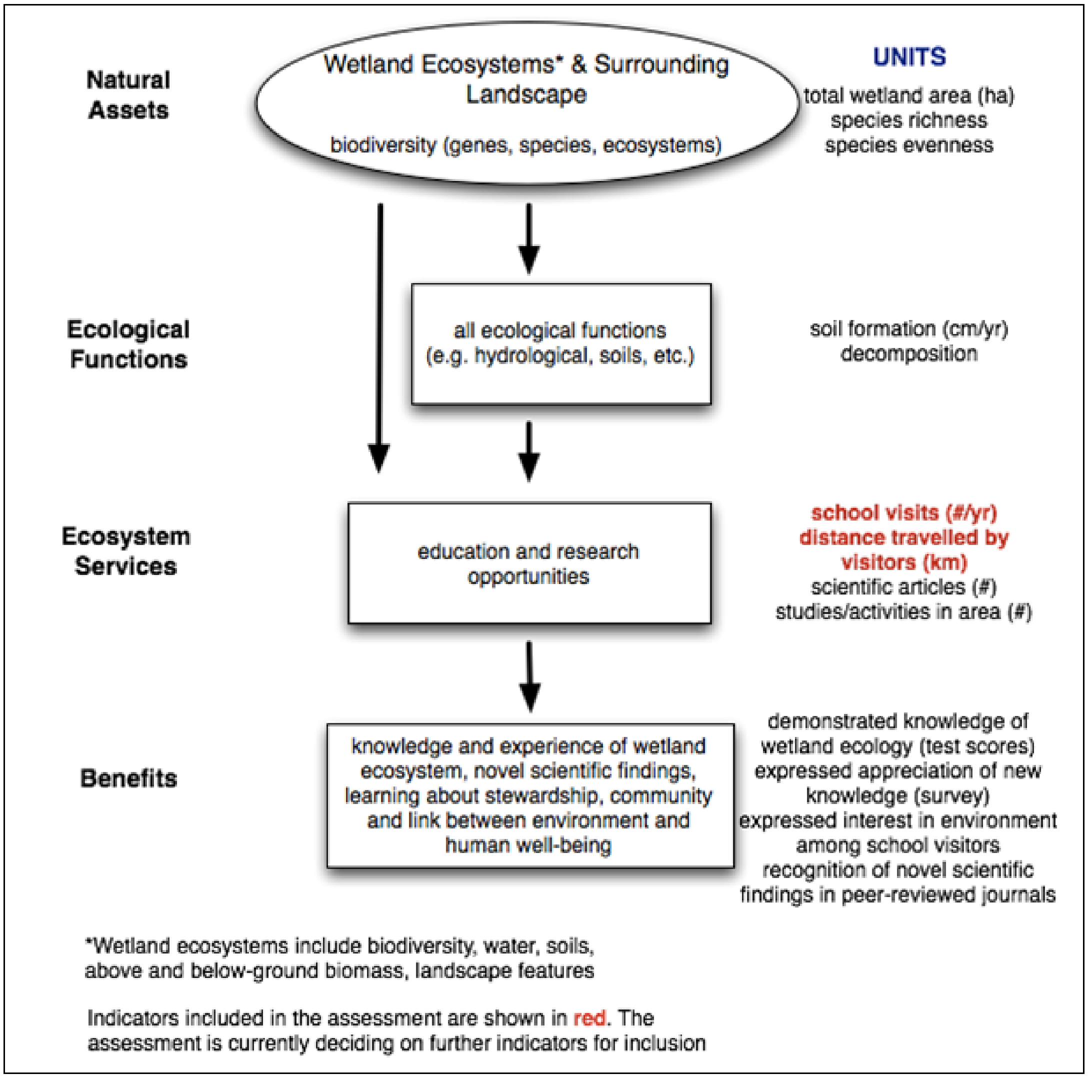


Figure 5.16 Ecosystem Services Cascade: Education Opportunities

5.7.1.3 Data Collection

RKP, located within the study area, is a 30.35-hectare (75-acre) wetland park. It provides educational and interpretive programs to visitors and serves as a scientific benchmark for research into natural processes and human derived change. Since its opening to the public in 2011, the park has received a lot of visitations from individuals, schools, and also professionals from other jurisdictions (e.g. Boston, US) to learn about the park (Thompson, 2011).

One of the programs offered by the park is school based learning programming that promotes awareness and encourages students to develop an appreciation of the natural world. The data on school visits for the school year 2011-2012 was collected from City of Calgary (McColl, 2011).

5.7.1.4 Results and Discussion

The school visits data provided by City of Calgary indicated that for 2011- 2012, 19 schools have scheduled their visits to RKP to take advantage of the educational programs available on site (McColl, 2011). An estimated 10,550 students are expected to visit the park in 2012 to participate in education programs (Thompson, 2011). Most of the schools are located in the City of Calgary, while there is one from DeWinton and one from Town of Chestermere. The distances traveled from schools to the Park (straight-line distance on the map) range from 5,046 meters to 26,635 meters with an average 17,077 meters (McColl, 2011). However, no monetary value estimates are conducted due to data limitations.

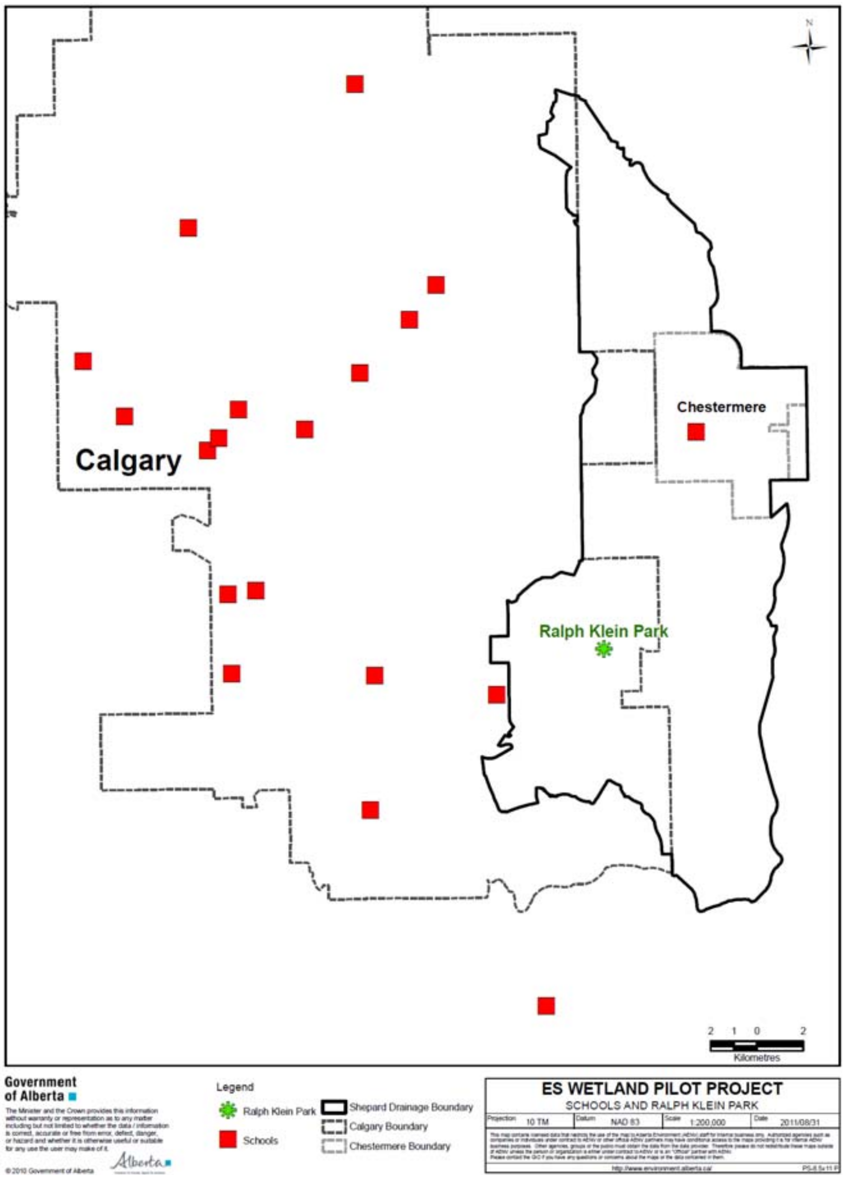


Figure 5.17 Distribution of School Visits to Ralph Klein Park

5.7.2 Pollination

Pollination is an ecosystem service that is provided by the function of the movement of floral pollinators (Olewiler, 2004). Though grasslands are the most important provider of pollinators, wetland ecosystems do help support pollinators and are often grassland adjacent. This makes estimating the value of pollination provided by wetlands only a difficult task. Nonetheless, although the value of pollination specific to Shepard Slough could not be estimated there is evidence to suggest it is an important ES. For example, in 1998, the value of honey bees as pollinators for Canadian crops was assessed to be $782 million (Canadian Honey Council, 2001). In southern Alberta canola is an important crop. Within the study area, canola and other oil seeds are the second largest agricultural activity by land use after cereal crops (Soil Landscapes of Canada, 2006). A large amount of pollination is done by commercial bee colonies, with some done by non-commercial bees. Bee colonies are a major component in the production of canola seeds. In 2008 there were 80,000 bee colonies under contract for the purpose of pollination in southern Alberta (Canadian Honey Council, 2009).

6 Land Value Mapping

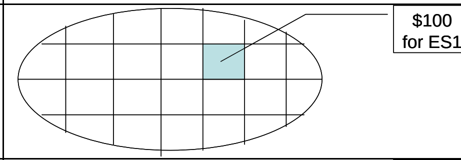
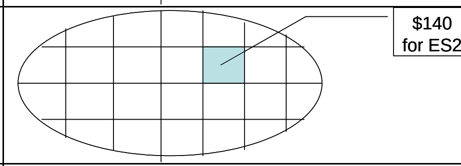
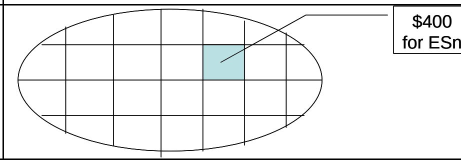
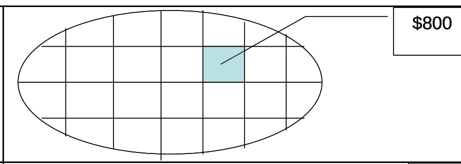
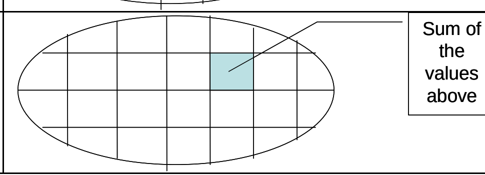
6.1 Land Value Mapping Approach

Young (2011) recommended land value mapping approach to reveal the land use trade-off associated with alternative land uses. Young also recommended a marginal valuation approach to examine such trade-offs. Land value mapping collates the value of ES of interest into a GIS based map. Developing a land value map requires both market and non-market methods since different types of ES are being valued. The basic premise is that each of the ES values is ascribed to a particular unit (e.g. hectare) and these values are then aggregated to produce an overall value map (Table 6.1).

The advantage of land value mapping is that it can show the distribution of values on the landscape that may be used to inform land use management decisions. For example, areas of higher ES values may be less ideal for alternate land uses than areas with lower values. However, one of the major challenges is deriving the monetary per unit value.

We further explored the use of a rating scale derived from a rapid wetland assessment tool to assist the economic valuation in Section 6.2.

Table 6.1 Land Value Mapping Approach

Ecosystem services[20]	**Physical value/biophysical importance score (scale per hectare per yr)**	**Economic value ($ per unit)**	**A particular wetland(s)**	**Values for that wetland(s)**	**GIS mapping**
ES_1	Scale 1-5	Scale 1=30, 2=50, 3=70, 4=90, 5=100	Scale 5	$100	
ES_2	Scale 1-5	Scale 1=30, 2=50, 3=70, 4=140, 5=300	Scale 4	$140	
…	…	…	…	…	…
ES_n	Scale 1-5	Scale 1=30, 2=50, 3=70, 4=160, 5=400	Scale 5	$400	
Land use values- hedonic pricing					
Other ES					
Value for the particular wetlands					

[20] ES_1-ES_n refer to ES with non-market values, such as Carbon sequestration, water provision, flood protection, etc.; other ES refer to market values revealed in land value, value at improvements.

6.2 WESPUS and Its Application in Economic Valuation

The Wetland Ecosystem Services Protocol for the United States (WESPUS) is a standardized method intended for use in rapidly assessing ecosystem services of all wetland types throughout temperate North America (Adamus, 2011). During the ES pilot project the Biophysical Sub-team completed WESPUS assessments for 21 different wetlands within the study area. A WESPUS-Valuation task team explored if WESPUS output could be used as the basis for economic valuation of wetland ES to develop a land value map. However due to time constraints and some questions related to reliability of WESPUS results, the focus shifted to developing the conceptual framework rather than conducting the valuation.

This section is to document the processes and lessons learned by the task team. It contains a proposed plan for developing a method to convert WEPUS results to economic values as well as possible opportunities, challenges and limitations to exploring its future applications in the Alberta context.

WESPUS-Valuation Method

The purpose is to integrate the WESPUS results into economic valuation by assigning economic values to WESPUS scores. In our exploratory stage, we have identified three major challenges in the process of integration.

WESPUS assessments results provide relative scores of effectiveness of 16 different wetland functions, including function scores and value scores. For this project we limited ourselves only to the identified priority ES such as water storage, flood control, water purification/quality, and carbon storage/sequestration. Conducting a WESPUS assessment of an individual wetland involves both a site assessment and a desktop assessment. Both assessment results are inputted into an excel spreadsheet, which then uses the assessed characteristics of the wetland into a set of formulas to derive the relative function and value scores. Fundamentally, the levels and types of *functions* that wetlands individually and collectively provide are determined by the processes and disturbances that affect the movement and other characteristics of water, soil/sediment, plants, and animals; the levels and types of *values* that wetlands provide, individually and collectively, are largely determined by the *opportunity* to provide a particular function and the local *significance* of that function (Adamus, 2011). For example, for water quality values, opportunity is determined by what's upslope of a wetland (e.g., land use and buffers in the wetland's contributing area) and significance is predicted partly by what's downslope (e.g., floodplains, water-quality limited water bodies).

However, the term *value* is defined slightly different in the ES Pilot as "the measure of the wellbeing associated with the change in the provision of an ecosystem service". Also *ecosystem services* are defined as "Outputs (goods and services) derived from ecosystems that benefit people"; in WESPUS, they are defined as "the combination of functions and the values of those functions, judged individually" (Adamus, 2011). In this study, *economic value* of wetlands ES speaks to both the level of provision of a particular ES and the associated change in human wellbeing. In that sense, none of the WESPUS function or value scores represent adequately for the relative magnitude of the ES value.

Challenge 1: <u>Concord of ES languages</u>. The project and WESPUS describe ecosystem services differently. In particular, some key terms are defined in slightly different ways (e.g. *ecosystem services*, *value*). Concord of terms, or at least a clear understanding of what various terms mean, is required to ensure a consistent approach prior to undertaking further work.

Challenge 2: Conversion of ES scores. As mentioned, WESPUS provides function scores and value scores. However, these scores are not adequately representative to compute economic value for a particular ES. It is not clear whether to use a function score, a value score or some combination of those scores for estimating economic value. This challenge was discussed with Dr. Paul Adamus of Oregon State University, who developed WESPUS. He proposed three options to convert the two streams of scores into one ES score:

- *Option A1*: The simplest but least defensible option is to just average the two.
- *Option A2:* A second option is to take the maximum of the function and value scores for a particular function.
- *Option A3:* A third option is to create sliding scales, wherein as function increases, points are gradually added to the existing value score or subtracted as function decreases.

Challenge 3: Assigning value estimates. With the generated relative scores for the condition/effectiveness of a particular ES, the next step is to assign economic values (in dollars). Hypothetically, there are various ways of assigning dollar values to a relative score. However, no research has been done to date to link the WESPUS scores to economic values in an explicit way.

Dr. Adamus proposed three ways to assign dollar values for value estimates:

- *Option B1:* Convert the WESPUS score to a decimal discount factor (e.g., a score of 7 on 0-10 scale becomes a coefficient of 0.7) and then multiplying it by dollar-per-hectare estimates of a particular wetland ES;
- *Option B2:* Generate willingness-to-pay estimates by polling the key stakeholders;
- *Option B3:* for water quality, multiply the decimal WESPUS function score by published estimates of the maximum reduction in pollutant load, then determine the cost of reducing that load to the same degree by using conventional infrastructure.

Based on Dr. Adamus's proposal and further discussion within the valuation team, Option A3 was chosen. The scale would be created by taking the maximum and minimum function scores for each ES assessed from the WESPUS results. For instance, if wetland #3 has the lowest water quality score of all assessed wetlands that becomes the Min of the function score range. If wetland #14 has the highest score that becomes the Max.

The next step is to conduct economic valuations for each. The idea is to find the equivalent between the WESPUS function score and an economic value estimate. This can be done either by conducting a literature review or by carrying out an onsite primary study using a proper traditional valuation method. Although not designed as such, WESPUS scores act essentially as per unit of measurement scores. Therefore if economic value estimates are in dollars per hectare then the WESPUS scores should be treated as a per hectare score. The scale is created by reconciling those two sets of numbers.

Choosing which WESPUS function scores to match the economic equivalent to, is not necessarily as straight forward as choosing the Max and Min of the score range. For example outlying scores that fall outside of a more or less continuous range most likely need to be excluded. This is especially true for the lower-value ones. When a WESPUS function score equals zero, it indicates not only its relative effectiveness is zero (small) but also its absolute effectiveness. Therefore wetlands with particularly low function scores should not be used as the Min. It should be acknowledged that the particular wetland function does occur as long as it is rated higher than zero, but that it is not very effective. However, there is no set rule for what ES scores to exclude from the scale and best judgment would be required.

Recommendation 1: Depending on how easy it is to find the equivalents between WESPUS function score and monetary value, it might be a good idea to do it a third time with the median WESPUS score along with the Max and Min. This would be done to better understand the relationship between WESPUS output scores and economic values. For example if a linear relationship is assumed between the scores and values, but the relationship is actually non-linear, the value will be overestimated except for the Max and Min (see Figure 6.1). Using the median WESPUS score in addition to max and min score to construct the relationship between function score and monetary value would allow a better understanding of that relationship and make the economic valuation results more valid.

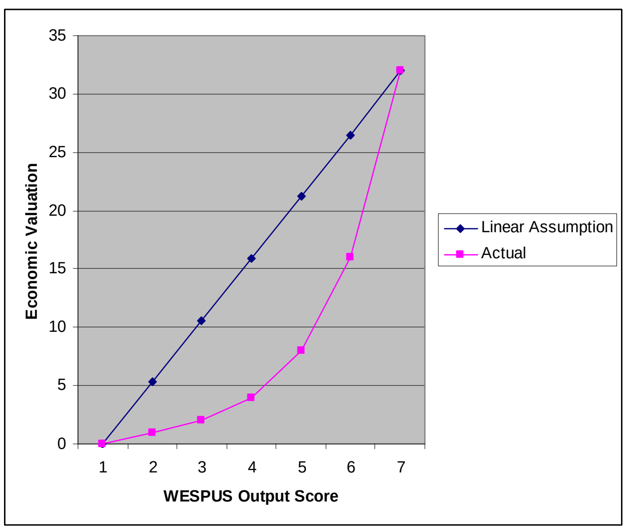


Figure 6.1 Relationship between WESPUS Scores and Economic Values
Note: This is just an example of a possible relationship, it could look very different from this and it is possible that a linear relationship does exist for a particular ES.

Recommendation 2: Formulas for generating function scores in WESPUS are most applicable to Class III and above wetlands in the Stewart and Kantrud classification system. Therefore it is recommended that this method be used for only Class III and above wetlands. Alternatively, the score scale needs to be recreated for Class I and II wetlands.

The next step in the process is to put the wetland function in its situational context. This is done using the WESPUS value score, which accounts for some of the landscape context in which the wetland is situated. WESPUS takes into account the area around the wetland within a two-mile radius. However it does not fully capture a wetland's physiological context on a regional scale, which might be important when understanding its role in a hydrological system for example.

Integrating the value scores is challenging, with two possible approaches being discussed by the task team. The first is to treat the value scores as a coefficient. The advantage to this approach is that it is the least time consuming and the ordering of economic values between the different wetlands would likely be valid. The disadvantage is that without further understanding of what comprises the value score, concerns over the validity of the estimate would remain subject to uncertainties. The other option is to break down the WESPUS formula and reconcile the variables in uses with relevant literature. Then based on the individual characteristics bonus points could be added to the function scores. This option addresses the potential validity concerns but is more time consuming.

Rational for Not Pursuing the WESPUS-Valuation Approach

Land value mapping using WESPUS scores was not conducted due to several shortcomings currently associated with WESPUS. These shortcomings along with recommendations to potentially address them include:

1. **WESPUS is not specific to the Alberta context:** An Alberta specific protocol may be developed for future use in Alberta. Spending time to develop the sliding scales for an assessment method that would be undergoing significant changes seemed unwise, because it would be necessary to redo much of the proposed work once the Alberta specific protocol has been implemented.

Recommendation 3: Conversion of WESPUS scores into economic values be put on hold until a similar protocol is developed for Alberta.

2. **Insufficient sample size of wetlands assessed:** Dr. Adamus suggested that roughly 50-60 wetlands are needed to develop a valid range for assigning relative scores to wetland functions. For this project 21 wetlands assessed. Furthermore, these sample wetlands may not be representative of the wetlands in the Shepard Slough area.

Recommendation 4: A method for WESPUS-Valuation should not be implemented until at least 50+ wetlands that are representative of the wetlands in the case study area have been assessed.

3. **Technical capacity and consistency in assessment:** One of the sample wetlands was assessed by two different teams separately. The scores between the teams varied, often considerably, for some of the assessed ES. For example, two teams had difference observations on whether there was an outlet. This had a significant impact, particularly on the function score of water quality. The impact was even more significant on the general results, because of the small sample size. This highlighted the lack of technical capacity and inconsistency in the implementation of WESPUS type assessment.

Recommendation 5: This gap could be filled by the combination of the Alberta oriented protocol and a strong training component for Alberta assessors to meet the need to produce consistent and valid results.

4. **Difficulty in developing a method for converting water quality function scores into monetary values:** WESPUS evaluates four functions that are related to water quality: Sediment retention and stabilization, phosphorus retention, nitrate removal and retention, and thermoregulation. Deriving an

economic value for this ES using WESPUS results proved to be the most challenging. Primarily, because of the complexity of integrating four functions into one function score. Dr. Adamus suggested choosing the water quality issue of most concerns, i.e. phosphorus retention in the study area, and use that as the score to base the valuation assessment. In addition, integrating the value scores is also a challenge. Because the value of a wetland to improve water quality is in a large part resulted from the surrounding area. Wetlands near heavy agriculture and industrial use may have higher nutrient loads.

Recommendation 6: For water quality, it is suggested to choose the issue of most concerns (such as phosphorus retention function score) as the water quality score. A combination of the scores for the three relevant functions could be used for more accuracy.

It is also important to point out one of the limitations of the WESPUS-Valuation approach. Wetlands of unique value (such as cultural heritage values) require further investigation on the value component because they are not explicitly addressed in WESPUS assessment. In general, there is a need for further exploration on some of the technical details as we recognize there are challenges.

7 Summary

This study attempted to obtain a more holistic picture of the benefits derived from wetlands by investigating a suite of ES. While we have attempted to be comprehensive in our analysis, it was not possible to assess all of the services and benefits that wetlands provide due to time and resource constraints. Instead we focused on key ES identified by the decision makers within the Pilot; and ES for which valuation approach was readily available. These ES likely account for most of the wetland services in the study area. A summary of the valuation results are provided followed by the economic methods used in this study along with data sources and limitations in Table 7.1.

Flood Control

Wetlands help mitigate impact of floods to surrounding areas. Wetland restoration cost and replacement cost of constructed wetlands were calculated as a representation of value for flood control benefits. Annual values were estimated assuming historic wetland loss rate (0.6% from 1962 to 2005) and future projected loss rate of 1.2%). The cost of replacing natural wetlands with constructed wetlands that would provide the same amount of flood control services was estimated to be about $338 million for the whole study area. This corresponds to an estimated $2 million per year in economic value losses under historic rate and about $4 million under projected loss rate. The estimated cost of restoring all wetlands on the landscape would be $43 million. This corresponds to an estimated $0.3 million per year in restoration costs under historic rate and $0.5 million under projected loss rate. However, it may be an underestimate of the real restoration cost as it only accounts for the cost of off-site restorations. The cost of restoration if occurring within the study area would be much higher due to high land acquisition costs proximate to the Calgary area.

Water Purification

Wetlands help filter nutrients and contaminants from reaching waterways. Nutrient management benefit was calculated for phosphorus, the nutrient of most concern in the Bow River. Replacement cost of both constructed wetlands and conventional water treatment systems were estimated as a comparison to wetland restoration cost. Annual values were also estimated assuming historic wetland loss rate of 0.6% and future projected loss rate of 1.2%. The cost of constructing wetlands to provide the same amount of water purification services supplied by natural wetlands was estimated to range from about $71 million to $347 million for the study area. This corresponds to an estimated $0.4 million to $2 million per year in economic value losses under historic rate and about $0.8 million to $4 million under projected loss rate. Conventional water treatment facilities would necessitate about $140 million to $650 million in costs. This corresponds to an estimated $0.8 million to $4 million per year in costs under historic rate and about $1.7 million to $8.3 million under projected loss rate.

Carbon Storage

Wetland soil stores organic carbon. However, loss of wetlands over the 1962 to 2005 period has resulted in loss of SOC at 44,144 Mg. The value estimates of carbon stored in wetlands vary considerably, with a range from a low of $608,552 to a high of $299 million, depending which valuation method is conducted. With the $15/tonne of CO_{2eq} in Alberta context, this amounted to $16.7 million for the study area. By applying a SOC loss of 89 Mg ha^{-1} as the amount of carbon re-emitted back to the atmosphere due to wetland drainage, the value of the SOC loss would range from $264,152 - $130 million. Given the $15 per tonne of CO_{2eq} the loss of value becomes $7.3 million if all wetlands were drained; the annual value loss became $44,000 and $87,000, at 0.6% and 1.2% of annual wetland loss rate, respectively.

Recreation

The annual value of recreation was estimated to be about $4.4 million based on an estimate of 114,685 participants each year and per person daily value of about $38. Most of the recreation value was associated with bird watching and outdoor recreation in signature sites in the Shepard Slough (e.g. Ralph Klein Park).

Aesthetic/Amenity

Two components, the value of adjacency (located next to a wetland) and the value of proximity (distance from the wetland) were assessed for two communities located in/around the case study area to examine the effect on aggregate house value. Adjacency to wetland was estimated to increase house value by $4,390 (1.14% of house value) in Copperfield and $5,136 (1.3% of house value) in McKenzie Towne. Aggregating this value across all the adjacent properties yielded value that ranged from $0.3 million to $0.8 million. The value of proximity was estimated to be $16.7 million for McKenzie Towne. Similar calculation was not performed for Copperfield due to model limitations.

Water Supply

Monetary value was not estimated due to limited direct beneficiaries of this ES and limited available data for further analysis.

Education/Scientific Opportunities

Monetary value was not estimated due to limited data availability and suitability of conveying monetary value for this ES. Education opportunity focused on Ralph Klein Park. An estimate of 10,550 students is expected to visit the park in 2012 to participate in education programs. Most of the visits originate from local and surrounding areas.

Pollination

Monetary value specific to the study area was not estimated due to limited understanding of role wetlands play in supporting pollinators and limited available data for further analysis. Nonetheless, there is evidence in previous studies to suggest it is an important ES.

Other ES and Benefits

In addition to those assessed in the study, there are other ES and benefits that are potentially associated with wetlands, such as air quality regulation, erosion regulation, heritage services, and some of the non-use benefits (existence, altruism and bequest value). Some were assessed by other evaluation teams such as the assessment of heritage services in the socio-cultural evaluation practice of wetland ES (see the '*Socio-cultural Technical Report*'). However, for the economic valuation component, we believe we have captured the most relevant ES to assist in wetland decision making for the study area.

Table 7.1 Summary of Selected ES, Valuation Methods, Data Sources and Limitations

Ecosystem Service	Valuation Method(s)	Value Measure(s)	Valuation Scale(s)	Data Source(s)	Limitations
Flood control	Wetland restoration costs	• Average value: $17,500 per ha • Total value: $43 million	• The study area • Sub-watershed	• Historic restoration data from DU (Scott, 2011) • Water storage capacity estimates from O2 Planning and Design (2011) • Average cost of constructed wetlands from the Shepard Constructed Wetland data • Flood risk assessment from O2 Planning and Design (2011) and Alberta Environment and Sustainable Resource Development	• Lack of understanding on the relationship between changes in wetlands and their ability to mitigate flood risk. • No 1:100 year floodplain data available within the study area. • Difficulties in quantifying which properties are protected from localized flooding due to the existence of wetlands without a detailed hydraulic model. • Residual impacts of regular stormwater management practices to hydrology or the chance of stormwater infrastructure failure causing destructive flood damages are both difficult to quantify.
	Replacement costs of constructed wetlands	• Average value: $252,000 per ha • Total value: $338 million			
	Flood risk evaluation	• No monetary value was derived			
Water purification	Wetland restoration costs	• Average value: $17,500 per ha • Total value: $43 million	• The study area • Sub-watershed	• Historic restoration data from DU (Scott, 2011) • Local stormwater runoff, nutrient loading and unit cost of nutrient removal estimates from AECOM (2011a) • Nutrient absorbing rates from a North American database • Nutrient removal effectiveness estimates of constructed treatment wetlands from Kadlec and Knight (1996) • Relative cost effectiveness of conventional treatment facilities vs. constructed treatment wetlands from White (n.d.)	• Wetland nutrient absorption rate derived from the literature due to lack of such data at the local scale. • Quantitative relationship on how changes of wetlands affect on the effectiveness of water purification services. • Local water treatment costs of nutrients were unavailable so literature derived values are used.
	Replacement costs of constructed treatment wetlands	• Average value: $28,908-$141,649 per ha per year • Total value: $71 million-$347 million per year			
	Replacement costs of conventional treatment facilities	• Total value: $141.6 million-694.1 million per year			

Ecosystem Service	Valuation Method(s)	Value Measure(s)	Valuation Scale(s)	Data Source(s)	Limitations
Carbon storage	Varied value measures of carbon	• Average value: ▪ \$2-\$982 carbon per tonne ▪ \$15/tonne of $CO2_{eq}$ (Alberta-based) • Total value: ▪ \$0.6 million-\$299 million ▪ \$16.7 million (Alberta-based)	• The study area	• Soil Organic Carbon (SOC) estimates from DU (Badiou, 2011a ; Badiou et al., 2011b) • Unit value of carbon estimates by Canadian Parks Council (Kulshreshtha et al., 2000) • Price of carbon credits in Alberta	• No complete inventory available on the wetlands with the Stewart and Kantrud Wetland Classification System • Underestimation of carbon storage in wetlands because only SOC was estimated by DU for Class III and above wetlands. There many wetlands that are unclassified and/or Classes I and II. • Carbon storage was estimated based on data from DU's reference wetlands which are not in the study area.
Recreation	Travel cost method	• Total value: \$4.4 million per year	• Site-specific (RKP)	• Travel cost survey conducted by the Pilot • Survey data from Alberta Tourism, Parks, and Recreation (2008) • Personal communications with a variety of groups (City of Calgary, Nature Calgary, etc.) • Data from the literature (Hvenegaard et al., 1989, etc.)	• The study site (RKP) was not fully operational at the time of this study and hindered the collection of travel cost survey data. Information from other sources (personal communications, previous studies, and literature) was necessary in the value calculation.

Ecosystem Service	Valuation Method(s)	Value Measure(s)	Valuation Scale(s)	Data Source(s)	Limitations
Aesthetic /amenity value	Hedonic pricing method	• Marginal value: ▪ Loss of $27 in house value if one additional meter away from a wetland ▪ Increase of $4,391-$5,136 in house value if adjacent to a wetland • Total value: ▪ $16.7 million for proximity ▪ $0.3 million - $0.8 million for adjacency	• Residential community based	• Property assessment and sales data from the City of Calgary	• Lack of data on some of house characteristics typically used in hedonic analysis, specifically the number of bedrooms and bathrooms. • The two communities selected are not fully developed for houses at the time of the study. This analysis excluded these empty land lots.
Water supply	Consumption of water by livestock	No monetary value was derived	• The study area	• Landscape classification and livestock data from SLC, Agriculture and Agrifood Canada • Land cover data from Grassland Vegetation Inventory (GVI) • Daily water requirement for livestock from O2 Planning and Design (2011)	• No quantifiable information on water consumptions in other sectors (e.g. agriculture) and the proportion of water that is drawn from wetlands. • Lack of information on what proportion of livestock water requirements are met by wetlands as compared to other sources (groundwater, streams). • No site specific information on which wetlands were used for livestock watering.
Educational /scientific opportunities	School visitations; travel distance	No monetary value was derived	• Site-specific (RKP)	• School visits data for RKP from the City of Calgary	• No data on visitation for educational and scientific purposes to other wetlands in the study area. • Data collection limited to school visits to Ralph Klein Park. • Limited responses to the travel cost survey.

Ecosystem Service	Valuation Method(s)	Value Measure(s)	Valuation Scale(s)	Data Source(s)	Limitations
Pollination	Benefit transfer	No monetary value was derived specific to the study area	• National wide	• Estimates from Canadian Honey Council and Agriculture and Agrifood Canada	• Lack of understanding on the quantifiable relationship between pollinators, agricultural productions and presence of wetlands. • No data on pollination, pollinators and crop productions at the local scale.

8 Input to Decision Making

The central theme of the ES Approach, in particular both the cultural and economic valuation components, is to ensure that the full range of ecosystems services and their values are reflected in decision-making process. The ES economic valuation contributes towards better decision-making, by ensuring that wetland approval process takes into account the benefits derived from the natural environment and by highlighting more clearly the implications for human wellbeing. However, with the recognition of economic value being one value among others (such as some of cultural values, assessed in the *Socio-cultural Technical Report*), the decision making process needs to integrate the whole suite of values to a possible extent and should not be reduced to economic value alone. Furthermore, ES benefits are context specific and economic values may vary significantly across the landscape. Therefore, the economic values derived from this study need to be understood and interpreted within the context of the study site.

Understanding the economic value of wetlands is important for making economically and environmentally sustainable decisions regarding wetland management. The resulting information can draw attention to the value of ES that might otherwise be ignored during decision making processes. Economic valuation is effective in communicating to decision makers and other stakeholders the value of wetland ES. Lack of knowledge regarding this value was one of the three gaps highlighted by the decision makers.

Economic valuation helps compare the costs and benefits of wetland ecosystem services versus engineering alternatives; evaluate the impacts of development policies on human wellbeing. However, this study did not intend to conduct a full cost-benefit analysis or other economic evaluation processes, which would imply a complete accounting of all costs and benefits associated with varied wetland management options. This can be done in the future.

In particular, the economic valuation study has helped address the three gaps by:

- **Demonstrating the economic values of wetlands with regards to major ES**

Even though the economic valuations of some ES were done at different scales than others, along with different valuation techniques used for different ES, the common message we can draw from these analyses is that wetlands are valuable to human wellbeing in terms of economic values for ES. The economic values of wetland regulating services (such as flood control, water purification and carbon storage) are tremendous and more economic effective compared to other engineering solutions. The economic values of cultural services (such as recreation) are also significant. These results can be a powerful tool to communicate the values of wetlands with different stakeholders that are involved in wetland management process, such as the public, developers, industries, municipalities, and governments at different levels.

- **Contributing to the consideration of cumulative effects and long-term consequences of decision-making**

With the demonstration of economic values derived from wetlands, it helps to inform trade-off decisions under the Cumulative Effects Management System (CEMS) and assure more robust decision making. For some ES, the distribution of economic value and annual value loss on a landscape map were calculated and presented, which can provide useful information in high-level strategic planning with the consideration of cumulative effects. For Example, flood control benefits wetlands between 0.1 and 1.0 ha account for over 8% of the total, which, although small, is almost as high as the total of those wetlands between 5 to 10 hectares (O2 Planning and Design, 2011). In terms of economic values, those wetlands also show a significant value of $27 million. Therefore, from a cumulative effects perspective, small wetlands do perform significant functions and represent high value to people when taken together as a whole.

In addition to the spatial dimension, there is enough flexibility for different development scenarios to be applied in the calculation and to show the corresponding consequences of different development paces. We used historic wetland loss rate (0.6%) and also projected the potential development pace by simply doubling the loss rate (1.2%) across the whole study area (sub-watersheds) in our calculation. This could be modified using more sophisticated scenario planning, such as assuming different development scenarios across sub-watersheds. This is extremely helpful for decision makers from both temporal and spatial perspectives when doing strategic planning at a sub-watershed and/or regional scale.

- **Providing evidence to support avoidance, minimization and compensation decisions on wetlands.**

Economic valuation of wetlands across the landscape can help identify heterogeneous value areas and thus identify priorities for wetland management decisions. From a management perspective wetlands of higher values could be linked to avoidance decisions compared to lower value which might support minimization or compensation decisions. Thus economic valuation of wetland within the ES framework can provide evidence to support the management hierarchy of wetland approval process and also wetland management planning at larger landscape scales.

9 Limitations and Caveats

This valuation study assisted in addressing the three gaps identified by the decision makers, however, some limitations and caveats remain. In spite of these limitations and caveats we believe that valuation provides useful information and can assist in making more informed wetland management decisions. Even if specific value estimates are further refined, the estimates provided remain valid for decision making. It is reasonable to believe though the value estimates from this study are a conservative estimate. In this case, valuation results are applicable for decision making for the study area only. This condition arises because ES benefits are context-specific as they relate as much to how the environment is valued as to how services are produced by ecological processes. These values for the same ES may vary significantly across the landscape. Therefore economic values derived in this study are specific to the study area and are not representative of all wetlands or wetland types in Alberta or elsewhere. In addition to various cost and benefit estimates for some ES, the Socio-econ Sub-team did not attempt to conduct a full cost-benefit analysis associated with varied wetland management options, which can be done in the future.

Although specific limitations and caveats are noted in relevant valuation sections, some common, overarching limitations include:

- Incomplete Scientific Understanding

Often the linkages between changes in ES and changes in human wellbeing are not well understood and this limited our ability to estimate and communicate value for some ES. Valuation provides a ‘snapshot’ of complex and dynamic system which is not necessarily in a state of equilibrium. We have assumed a static model in the sense that the value of each service is derived independently. This ignores the complex interdependencies between ES. Furthermore, most valuation studies, including this study, are undertaken with the assumption that there are no thresholds, discontinuities, or irreversibilities in the ecosystem functions. That is small changes in ecosystems would result in small changes in their services without fundamentally altering the ecosystems. This may not always be true since cumulatively small changes could lead to substantial changes in the services as the system moves through critical thresholds. Further work to understand the cumulative effects and critical thresholds is needed.

- Data and Resource Constraints

Projects are often subject to data and/or resource constraints; this project is no exception. In practice this constraint has influenced the choice of valuation methods and in some cases this meant a 'second best' valuation method was used. In some cases, the use of benefits transfer was required due to lack of locally relevant data, including biophysical and socio-economic data. Although reasonable care was taken in applying literature derived values, further work to refine and calibrate those values to local context is recommended.

- Inadequate Coordination and Integration

A project of this size and scope involves multiple teams and disciplines, each of which should understand the interdependencies among their work and the needs to effectively deliver their work. As this was a pilot project geared to develop an Alberta specific Ecosystem Service Approach, a significant amount of time was spent framing the project within that context. In addition, the lack of capacity within the pilot team to do biophysical assessments delayed the deliver of biophysical assessment results. Since the output of that assessment serves as an input into economic valuation, particularly for regulating services, timeline for doing that valuation was shortened significantly. It is crucial to have better coordination and integration among work tasks as well as effective allocation of limited resources. A need for awareness of the dependency on biophysical assessment outputs to conduct economic valuation for is also highlighted.

- Value Measure and Aggregation

An aggregate value of all selected ES for the study area is not provided for several reasons. First, the scale of valuation varied depending on the ES being valued. Second, value measure (e.g. total, average, marginal value) differed amongst the ES valued and different value measures cannot be aggregated even though they are all expressed in monetary units. Although more data intensive, marginal valuation is more appropriate measure in decision making as resource use decisions deal with incremental changes, thus marginal valuation approach is recommended for future study.

- Valuation Scale

Scale of valuation is an important consideration. There is no literature guidance on the appropriate scale, spatial and temporal, for valuation. In practice valuation is often bounded by the scale of biophysical assessment. In many cases the spatial scale is often at the sub watershed or watershed scale. However, determining temporal scale for valuation is not straightforward. In general, the temporal period should encompass at least the current beneficiaries of the ES. However, it will be important to also consider future beneficiaries particularly in regards to inter-generational sustainability.

- Values Not Captured by Economic Valuation

While we have attempted to be comprehensive in our analysis, only a suite of most relevant ES in the study area was assessed due to time and resource constraints. With the analysis to continue focusing on locally relevant ES to assist in the decision making process, a broader suite of ES categories could be assessed to gain a holistic picture of all wetland ES and benefits in future studies. It is also acknowledged that ecosystems are considered to have intrinsic value, independent of the services they provide to humans. However, it is beyond the scope of this study to assess this type of value.

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11 Glossary of Key Terms

Term	Description
Altruism Value	The value individuals attach to the availability of ecosystem resource for others in the current generation. An example of *Non-use Value*.
Beneficiary (of Ecosystem Services)	Persons, groups or projects that benefit from ecosystem services in tangible or intangible ways.
Benefit	Positive change in human wellbeing from the delivery of ecosystem services.
Bequest Value	The value individuals hold regarding the availability of resources for future generations. An example of *Non-use Value*.
Biodiversity	The variability among living organisms and the ecological complexes of which they are a part. This includes the diversity found within and between species and between ecosystems. Biodiversity serves as the foundation for all *Ecosystem Services*, which are dependent to some degree on the diversity of genes, species, populations, communities, landscapes and information, or on key components of biodiversity include food, genetic resources, timber, biomass fuel, and ecotourism.
Consumptive Use	The reduction in the quantity or quality of a good available for other users due to consumption.
Cultural Services	The non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience, including, e.g., knowledge systems, social relations, and aesthetic values.
Cumulative Effects	The combined effects on the environment arising from the combined impacts of all past, present, and reasonably foreseeable future human activities.
Direct Use Value	The value derived from the services provided by an ecosystem that are used directly by an economic agent. These include *Consumptive Uses* (e.g., harvesting goods) and *Non-consumptive Uses* (e.g., enjoyment of scenic beauty). An example of *Use Values*.
Driver (Direct, Indirect)	Any natural or human-induced factor that directly or indirectly causes a change in an ecosystem.
Ecological Functions	Natural processes that are necessary for the self-maintenance of an ecosystem and its integrity, such as primary production, nutrient cycling, decomposition, etc.
Economic Valuation	The attempt to elicit public preferences for changes in the state of the environment through analytical techniques where these preferences are quantified into monetary equivalents or other appropriate units.
Economic Value	The measure of the wellbeing associated with the change in the provision of an ecosystem service quantified in monetary or other appropriate units. It is not synonymous with monetary value.
Ecosystem	An ecosystem is a dynamic complex of plant, animal, and microorganism communities and the nonliving environment interacting as a functional unit.
Ecosystem Goods and Services	It is synonymous with '*Ecosystem Services*'.
Ecosystem Services	Outputs (goods and services) derived from ecosystems that benefit people. These include provisioning services, regulating services, supporting services, and cultural services. Ecosystems, and the biodiversity contained within them, provide a stream of goods and services essential for society's well-being.

Ecosystem Services Approach	An Ecosystem Services approach provides a framework by which ecosystem services are integrated into public and private decision making. The approach included the following components: identification of problem or issue, identification of ecosystem services being provided, dependency and impact assessment, condition and trend assessment, economic valuation of services, identification of risks and opportunities, input into decision making.
Ecosystem service impact	A project, plan or policy *impacts* an ecosystem service if actions associated with the project, plan or policy alter the quantity or quality of a service.
Existence Value	The value individuals derive from the knowledge that an ecosystem resource exists, even though they will never see it or use it. An example of *Non-use Values*.
Indirect Use Value	The value derived from the goods and services provided by an ecosystem that are used indirectly by an economic agent. For example, drinking water that has been purified as it passed through the ecosystems. An example of *Use Values*.
Intrinsic Value	The worth of a good or service for its own sake, independent of the benefits they may yield to humans.
Marginal Value	The change in economic value associated with a unit change in output, consumption or some other economic choice variable.
Market Value	The value of a good or service determined in a market and expressed in monetary terms (prices).
Natural Asset	The stock of natural resources from which many ecosystem services are produced.
Non-consumptive Use	Using a resource in a way that does not reduce its supply in quantity or quality, such as hiking, bird watching and other recreation activities.
Non-market Value	The value of a good or service recognized by people but not transacted in a market place.
Non-use Value	The value that is derived from the knowledge that the natural environment is maintained. This comprises *Bequest Value, Altruistic Value* and *Existence Value*.
Option Value	The value that people place on having the option to use a resource in the future. An example of *Use Values*.
Opportunity Cost	The benefits forgone by undertaking one activity instead of another.
Passive Use Value	The values that are enjoyed vicariously, without having to directly or indirectly use a good or visit a site. This comprises *Option Value, Bequest Value, Altruistic Value* and *Existence Value*.
Project Stakeholder	A person, group or organization with a common interest in a project and its outcomes, where stakeholders may or may not be involved in the delivery of a project, and may or may not be an ecosystem services beneficiary.
Provisioning Services	The products obtained from ecosystems, including, for example, genetic resources, food and fiber, and fresh water.
Public Good	A good or service in which the benefit received by any one party does not diminish the availability of the benefits to others, and where access to the good cannot be restricted.
Quasi-option Value	The welfare gain associated with delaying a decision when there is uncertainty about the payoffs of alternative choices, and when at least one of the choices involves an irreversible commitment of resources. Stems from the value of information gained by delaying an irreversible decision to develop a natural environment. (See also *Option Value*)
Regulating Services	The benefits obtained from the regulation of ecosystem processes, including, for example, the regulation of climate, water, and some human diseases.

Scenario	A plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about key driving forces (e.g., rate of technology change, prices) and relationships. Scenarios are neither predictions nor projections and sometimes may be based on a ‘‘narrative storyline.’’ Scenarios may include projections but are often based on additional information from other sources.
Supporting Services	Ecosystem services that are necessary for the production of all other ecosystem services. Some examples include biomass production, production of atmospheric oxygen, soil formation and retention, nutrient cycling, water cycling, and provisioning of habitat.
Threshold	The value of an indicator that reflects a problem condition in an ecological, economic, or other system. Thresholds at which irreversible changes occur are especially of concern to decision-makers.
Total Economic Value (TEV)	The total gain in wellbeing from a natural resource. It comprises *Use Value* (including *Direct Use Value, Indirect Use Value, Option Value),* and *Non-use Value (*including *Existence Value, Altruistic Value, Bequest Value)*.
Trade-offs	Management choices that intentionally or otherwise change the type, magnitude, and relative mix of services provided by ecosystems.
Use Value	The value that is derived from using or having the potential to use a resource. This comprises *Direct Use Value, Indirect Use Value* and *Option Value*.
Utilitarian	An approach that focuses on the satisfaction of human preferences.
Utility	In economics, the measure of the degree of satisfaction or happiness of an individual.
Valuation	The process of expressing a value for a particular good or service in a certain context (e.g., of decision-making) usually in terms of something that can be counted, often money; can also be described in qualitative terms, using methods and measures from other disciplines (sociology, ecology and so on).
Value	Generally, the worth, merit or desirability of an ecosystem service to human. In economics, it is the measure of the wellbeing associated with the change in the provision of an ecosystem service. In social context, it is the appreciation or emotional value attached to a given ecosystem service. It can be expressed quantitatively or qualitatively (either in economic terms or ethically).
Well-being	A context- and situation-dependent state, comprising basic material for a good life, freedom and choice, health, wealth, good social relations, and security.
Wetland	Land saturated with water long enough to promote wetland or aquatic processes as indicated by the poorly drained soils, hydrophytic vegetation, and various kinds of biological activity that are adapted to a wet environment.
Wetland Compensation	Payment into a fund for wetland restoration work.
Wetland Loss	Includes infilling, altering, or physically draining a wetland, any impact to the riparian area or buffer strips, and any type of interference with the hydrology to and from a wetland.
Wetland Mitigation	A process to reduce the loss of wetlands, focusing on avoiding loss, minimizing impact, and compensating for unavoidable wetland loss.
Wetland Restoration	The re-establishment of a naturally occurring wetland with a functioning natural ecosystem whose characteristics are as close as possible to conditions prior to its drainage or alteration.

12 Appendices

Appendix 1 Definitions of Total Economic Value Categories

Total Economic Value comprises two big categories: use and non-use values.

Use value refers to the value that is derived from using or having the potential to use a resource, either directly or indirectly. It includes direct use, indirect use and option value:

- Direct use value: where individuals derive value from direct use of the services provided by an ecosystem. This can be in the form of consumptive use which refers to the use of resources extracted from the ecosystem (e.g. food, timber) and non-consumptive use, which is the use of the services without extracting any elements from the ecosystem (e.g. recreation, landscape amenity). These activities can be traded on a market (e.g. timber) or can be non-marketable i.e. there is no formal market on which they are traded (e.g. recreation or the inspiration people find in directly experiencing nature).

- Indirect use value: where individuals benefit from ecosystem services without directly using it. These ecosystem services include climate regulation; water regulation; pollution filtering; soil retention and provision; waste decomposition; and pollination. Measuring indirect use values is often significantly more challenging than measuring direct use values. Changes in the quality or quantity of a service being provided are often difficult to measure or are poorly understood.

- Option value: the value that people place on having the option to use a resource in the future. These future uses may be either direct or indirect. An example would be a national park where people who have no specific intention to visit it may still be willing to pay something in order to keep that option open in the future. In the ES context, option value describes the value placed on maintaining ecosystems and their component species and habitats for possible future uses, some of which may not yet be known.

Non-use value is derived from the knowledge that the natural environment is maintained. There are three main components:

- Altruism value: where individuals attach values to the availability of the ecosystem resource to others in the current generation.

- Bequest value: where individuals attach value from the fact that the ecosystem resource will be passed on to future generations.

- Existence value: derived from the existence of an ecosystem resource, even though an individual has no actual or planned use of it. For example, people are willing to pay for the preservation of whales, through donations, even if they know that they may never actually see a whale.

Quasi-option value is an additional element of value. Quasi-option value refers to the value of information secured by delaying a decision, where outcomes are uncertain and where there is opportunity to learn by delay. In the context of uncertainty and irreversibility, it may pay to delay making a decision to commit resources. Although quasi-option value lies outside the TEV framework, it represents the value/benefit of better decision-making where there is potential to learn by delaying a decision. The OECD's 2006 review, Cost-Benefit Analysis and the Environment: Recent Developments shows that quasi-option value is particularly relevant in the context of ecosystems –there is uncertainty, irreversibility and a major chance to learn through scientific progress in understanding better what ecosystems do and how they behave (UK DEFRA, 2007). For example, the development of a piece of wetland for agricultural use may result in known benefits in terms of crops that can be valued at market prices. The benefits of preserving the same piece of wetland may be unknown. Delaying the decision on the land development may enable us to learn more about the likely benefits of preserving the land (e.g. if it provides important ES such as flood attenuation for local communities). In such a situation, quasi-option value describes the benefit of the additional information that can be learned by delaying the decision to develop. However, finding examples of estimated quasi-option value in environmental economics literature is limited and further study is required.

Appendix 2 Economic Valuation Techniques

Economic valuation attempts to elicit public preferences for changes in ecosystem services, mostly in monetary terms. Valuation approaches can be organized into Revealed Preference and Stated Preference methods.

Revealed preference (RP) methods rely on data on actual behaviour and consumption patterns regarding individuals' preferences for a marketable good which includes environmental attributes. These techniques rely on actual markets. Included in this approach are: market prices, production function, travel cost, hedonic pricing, replacement cost, avoided damage cost, and human capital methods.

The values of environmental assets traded in existing markets are determined by Market prices driven by supply and demand and production costs. Production function method is used to evaluate environmental quality impacts on a good's production costs. Revealed and stated preference methods within surrogate and hypothetical markets are used to capture values of ecosystem services that are not market-traded. Hedonic pricing method is used to determine the value of environmental assets via market-traded goods. For instance, houses located near natural environments are in greater demand. Travel cost method determines the value of environmental assets via travel expenditures for recreation. Replacement cost method uses potential expenditures incurred in replacing/restoring the function of wetlands that is lost. Avoided damage cost method estimate defensive expenditures by evaluating the cost of avoiding damages as a result of adverse environmental impacts such as flooding by maintaining or restoring wetlands. Human capital method calculates the equivalent value of the loss of earnings or life that would result if the services were not effective.

Stated preference (SP) methods use carefully structured questionnaires to elicit individuals' preferences for a given change in a natural resource or environmental attribute. In principle, SP methods can be applied in a wide range of contexts and are the only methods that can estimate non-use values which can be a significant component of TEV for some natural resources. Included in this approach are: contingent valuation, contingent behaviour, contingent ranking and choice modeling.

Contingent valuation method uses willingness to pay questions on hypothetical situations to determine the value of environmental assets and ecosystem services. It is the most widely used method for estimating non-use values. Choice experiments involve ranking and scoring selected environmental assets or ecosystem services and their estimated values allowing for the analysis of preferred environmental policy options. A comparing and ranking environmental asset restoration programs with different outcomes is an example of a choice experiment. Contingent behaviour involves construction of a hypothetical scenario in surveys for a sample of individuals, asking them to directly state their behaviour changes; while Contingent ranking asks individuals to rank several alternatives in surveys that comprise various combinations of environmental goods and prices.

Some valuation methods may be more suited to capturing the values of particular ecosystem services than others. For example, market prices are often used for valuing provisioning services, while stated preference studies are well suited to capturing non-use values (e.g. existence value of a rare species). In many valuation contexts, more than one technique is likely to be employed (for example, the direct-use values of cultural services may be captured by revealed preference methods such as travel cost, while stated preference methods will capture the non-use values associated with cultural services). The method(s) used will very much depend on the services being valued and their context (UK DEFRA, 2007).

Benefits transfer is a process by which the economic values that have been generated in one context are applied to another context for which values are required. It refers to a collection of methods rather than a single approach. Values derived from one or more study sites can be transferred to a policy site in different ways (US EPA, 2009; UK DEFRA, 2007). A unit-value transfer usually interprets an estimate of the trade-off people make for a change in ecosystem services as locally constant for each unit of change in the ecosystem service. A function transfer approach replaces the unit value with a summary function describing the results of a single study or a set of studies. While there are good examples of the use of benefits transfer in policy appraisal, the validity and accuracy of benefits transfer is a key issue. It is often used when it is too expensive and/or there is too little time available to conduct an original valuation study, yet some measure of benefits is needed. There is a need for improved understanding of when transfer works and when it does not, as well as reviewing options that would improve the accuracy of benefits transfer.

Appendix 2 Assessment of Valuation Techniques

Table 12.1 Assessment of Economic Valuation Methods

Valuation Method	*Element of TEV Captured*	*Ecosystem Services Valued*	*Advantages*	*Limitations*	*Timeline*[21]
Revealed Preference Methods					
Market prices	Direct and indirect use	Those that contribute to marketed products (i.e., provisioning services and some cultural services) e.g. timber, fish, genetic information.	Market data readily available and robust.	Limited to those ecosystem services for which a market exists (i.e., provisioning services and some cultural services); Market imperfections and/or policy failures may distort market prices; Seasonal variations and other effects on prices need to be considered; Can undervalue environmental resources.	Can be completed in 1 month.
Travel cost methods	Direct and indirect use	Recreation, tourism.	Based on observed behaviour; Suited for well-defined recreational sites / activities, or separable, well-perceived environmental attributes influencing such sites and activities.	Limited to some cultural services; Can overestimate if a trip is made for many purposes; Data intensive; Restrictive assumptions about consumer behaviour (e.g. multifunctional trips); Results highly sensitive to statistical methods used to specify the demand relationship.	Can take 4-8 months to complete.
Hedonic pricing methods	Direct and indirect use	Aesthetics; also has the potential to value other ecosystem services (e.g., storm protection, groundwater recharge, clean air, water availability) in terms of their impact on land values.	Market data available through municipal property assessment or realtor association	Very data-intensive and limited mainly to services related to property prices; Can undervalue environmental resources in that improved environmental quality is reflected only in property prices.	Can take 3-6 months to complete.
Production function methods	Indirect use	Any services that serve as input to market product, e.g., effects of air, water, and soil quality on productive activities such as fishing, hunting and	Market data readily available and robust.	Requires a clear and quantified understanding and explicit modeling of the “dose-response” relationship between the service and the product; Data-intensive and data on changes in services and the impact on production often missing; Problems	Can take 3-12 months to complete.

[21] Timeline includes time for data acquisition and data analysis. Timelines presented here are meant to convey relative ranking, in terms of time required, amongst the methods. Actual time required is project specific and could differ from timelines presented here.

Valuation Method	Element of TEV Captured	Ecosystem Services Valued	Advantages	Limitations	Timeline[21]
		farming.		may arise from multi-specification of the ecological-economic relationship or double counting.	
Avoided Damage cost	Direct and indirect use	Flood control, shoreline protection services, erosion reduction, etc.	Precautionary principle applied here.	It is assumed that the costs of avoided damage or substitutes match the original benefit. However, this match may not be accurate, which can lead to underestimates as well as overestimates. Data or resource limitations may rule out first-best valuation methods.	Can take 3-6 months to complete.
Replacement cost	Direct and indirect use	Water filtration, erosion control, groundwater recharge.	Market data readily available and robust; useful in estimating indirect use benefits when ecological data are not available for estimating damage functions with first-best methods.	Can potentially overestimate actual value.	Can take 3-6 months to complete.
Cost of illness (human capital approach)	Direct and indirect use	Any impact that affects health, applicable to regulating services such as the absorption of toxins and pollutants in air or water or the control of diseases.	Applicable to all services that affect health.	Variety of valuation measures available, (e.g. value of statistical life, quality adjusted life years) so analyst need to ensure appropriate value measure is selected.	Can take 6-18 months to complete.
Stated Preference Methods					
Contingent valuation method	Use and non-use	All ecosystems services.	It is flexible and facilitates the valuation of a wide range of non-market goods and services. This technique allows for examination of ‘what if’ scenarios to assess the changes in well being of different policy options.	Subject to various sources of bias and high uncertainty in survey design and implementation; Resource-intensive method, hypothetical nature of the market.	Can take 12-18 months to complete.

Valuation Method	Element of TEV Captured	Ecosystem Services Valued	Advantages	Limitations	Timeline[21]
Contingent behaviour	Use and non-use	All ecosystems services.	See Contingent valuation.	Subject to various sources of bias and high uncertainty in survey design and implementation; Resource-intensive method, hypothetical nature of the market.	Can take 12-18 months to complete.
Contingent ranking	Use and non-use	All ecosystems services.	See Contingent valuation.	Subject to various sources of bias and high uncertainty in survey design and implementation; Resource-intensive method, hypothetical nature of the market; Does not elicit willingness to pay directly, hence lacks theoretical advantages of other stated preference approaches; Being qualitative.	Can take 12-18 months to complete.
Choice experiment	Use and non-use	All ecosystems services.	See Contingent valuation. In addition, Choice experiment is more flexible, as many more potential combinations of environmental change can be presented to respondents which can allow for a better incorporation of uncertainty surrounding changes in ecosystem services. Also trade offs can be explicitly modeled.	Bias in responses, resource-intensive method, hypothetical nature of the market.	Can take 12-18 months to complete.
Other Methods					
Benefits transfer	Use and non-use	Any service for which suitable comparison studies are available.	Used (but with caution) when time and resource to carry out primary research is scarce and/or data is unavailable.	Values are site and context dependent and therefore in principle not transferable. Degree of error associated with transferring values obtained from one site (original site) to study site being examined. Not applicable where greater accuracy of valuation is required.	Can take up to one month.

(Source: Anderson et al (2010); Ranganathan et al (2008); Ash et al (2010); Ramsar (2006); CBD (2007); UK DEFRA (2007); TEEB (2010) ; Barbier (2007); de Groot et al (2002); Neupane (2010)

Appendix 3 Recreation Survey

Ecosystem Services Approach Pilot on Wetlands

You are invited to participate in a brief survey to determine recreational activities associated with wetlands. Wetlands generally include swamps, marshes, bogs and similar areas. Wetlands have been recognized as providing ecosystem services and benefits, such as recreational or educational opportunities, flood mitigation, or water quality improvements. Alberta Environment and Sustainable Resource Development are conducting this survey as part of its Ecosystem Services Program to support the cumulative effect management system. The information collected from this survey will be used to understand how and why wetlands are important to people, and the results will be used to inform wetland management in the Shepard Slough area.

The survey will take a few minutes to complete. The survey asks you about your hometown and postal code, information about distances and expenses incurred to travel to this wetland, and general demographic information. This information is being collected under the authority of Sections 8(1) and (2) of the *Government Organization Act*, and in accordance with Section 33 (c) of the *Freedom of Information and Protection of Privacy Act*. We will keep this information only for the length of time necessary to fulfill the purpose for which it was collected. An internal project report will be produced; however, no personally identifying information will be used in the report. A summary report of the project and findings may be released to the public. Again, no personally identifiable information will be used in the report.

Questions regarding this research may be addressed to Gillian Kerr, Ecosystem Services Manager, Alberta Environment and Sustainable Resource Development (Phone: 780-644-7965 or Email: gillian.kerr@gov.ab.ca). By completing this survey you agree that you have read and fully understand the above information, and provide consent to participate in the survey.

Thank you for your participation in the survey. Your contribution is greatly appreciated.

Which city/town did you travel from: ____________________________Province:_________

Postal Code: ____________ If outside of Canada, which country: ____________ , go to question #5)

1) What approximate distance did you travel to get here _______ km or ________ miles

2) How did you get here (Select all that apply)?

___ Self-owned Vehicle ___ Rental Vehicle ___Car Pool ___On Foot ___ Bike

3) How many people are you traveling with? ____________

4) Is this site your primary destination for this trip? ____Yes ___ No If no, how many other sites do you plan to visit ____

5) Please indicate the types of recreational activities that you participated in this wetland (Select all that apply).

___Walking/hiking ___ Bird watching ___ Biking ___ Scenic Viewing ___ Other _____________

6) Please indicate the number of visits to wetlands during the last 12 months for recreation purposes.

Jan. _______ Feb. _______ Mar. _______ Apr. _______ May. _______ Jun. _______
Jul. _______ Aug. _______ Sept. _______ Oct. _______ Nov. _______ Dec. _______

6a) What proportion of those visits was to this specific wetland? _________%

7) If this wetland was not available for your recreation, are there alternative wetlands you would visit for recreation? _______Yes _______No

7a) If yes, are these alternative wetlands within
_______0-2 km; _______3-5 km; ________ 6-10 km; ________ greater than 10 km

8) Do you visit wetlands for education or artistic purposes? _______Yes _______No

8a) If yes, what type of educational/inspirational activities do you participate in (Select all that apply)?

___ Interpretive Walk/Hike ____Wildlife Identification ___Learning about ecosystems ___ Painting
____Photography ___Music ___Poetry ___ Other (please identify) ____________________

8b) If yes, do you visit this specific wetland for these purposes? _______Yes _______No

9) What is your total approximate expense incurred for this visit (e.g. gas, equipment)? Please include only equipment expense incurred this year. $_____________

Annual household income before taxes	Highest level of formal education completed	Employment status
__ Under $30,000 __ $30,001 - $50,000 __ $50,001 - $80,000 __ $80,001 - $100,000 __ Greater than $100,000 Gender ____M ____F	__less than high school __ Secondary (high school or equivalent) __ Post secondary (college, university) __ Graduate (Master’s or PhD)	__ Unemployed __ Employed part time (less than 40 hours/week) __ Employed full time (more than 40 hours/week) __ Student __ Self employed __ Retired

Appendix 4 Survey Brochure

Why Study Ecosystem Services

The Ecosystem Services Approach Pilot on Wetlands will provide tool(s) to enhance decision making in order to:

- transition to cumulative effects management;
- explore ways to provide social, economic and environmental perspectives to information land-use decision making; and
- examine some of the important benefits that society receives from nature that may not be recognized.

Once the pilot is complete, there will be a better understanding of how to use the Ecosystem Services approach and where the approach to support Alberta Environment priorities.

Contact Us

General Questions about the Ecosystem Services Approach Pilot on Wetlands:

Gillian Kerr
Ecosystem Services Manager
Alberta Environment
Phone: 780-644-7965
Email: gillian.kerr@gov.ab.ca

Survey Questions:

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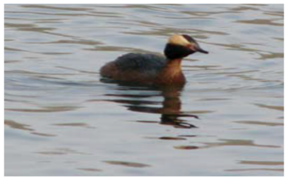
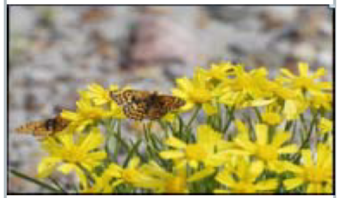
Research Consultant
Phone: 403-329-2535
Email: r.bewer@uleth.ca



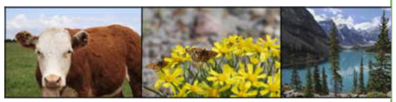
Alberta Environment (2011)

Ecosystem Services

Pilot Study of Recreational and Educational Uses of Shepard Slough Wetlands



Ecosystem Services in Shepard Slough Wetlands: Survey of Recreation



As part of its Ecosystem Services (ES) Program, Alberta Environment has undertaken an ecosystem services approach pilot project on wetlands in the greater Shepard Slough area of east Calgary/ Rocky View County. This region provides many recreation and education opportunities to people such as birding, nature walking, and field trips to the region.

To better understand the recreation and education benefits enjoyed in the Shepard Slough area, a survey of recreation participation is being conducted.

Through this survey, valuable information will be collected including travel distances, costs of travel, and types of activities preferred by users.

Anyone that enjoys visiting wetlands in the Shepard Slough, including Ralph Klein Park, for recreation and education purposes is encouraged to complete the survey. It can be completed onsite or online at:

https://sites.google.com/site/aenvshepardsurveyrkp/

Definitions

Ecosystem: A dynamic complex of plant, animal, and microorganism communities and the nonliving environment interacting as a functional unit.

Ecosystem Services: The benefits that people get from nature.

Ecosystem Services Approach: An assessment method that can be used to provide an understanding of the services that ecosystems provide to people, and how this might inform decision-making.

Benefits: Positive change in human well being from the delivery of ecosystem services.