

A Convenient Truth:
The Environmental Benefits of Local Government Infrastructure Asset Management in
British Columbia

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Executive Summary

Purpose of the Report

This report has two primary objectives. The first is to identify the environmental benefits of implementing infrastructure asset management principles at the local government level. This is important in that it provides an environmental rationale to local governments for the practice of infrastructure asset management, in addition to the financial and social rationales that have been discussed widely in the literature.

The second key objective of this report is to identify the state of asset management in BC, including the extent to which asset management is used to achieve municipal environmental objectives. This was undertaken because the state of asset management in BC was unknown, and also in order to explore the ways in which the Province might support local governments in using infrastructure asset management as a tool for environmental sustainability.

Definition of Asset Management

Fundamentally, infrastructure asset management supports fiscal sustainability as it eliminates a primary cause of municipal infrastructure deficits: short term decision-making that does not plan for the future financial costs of operating, maintaining, refurbishing, and renewing infrastructure assets. In contrast, asset management requires that decisions be made with consideration of the lifecycle costs of infrastructure related investments, as securing the funding of those future costs is a primary aim of asset management.

Infrastructure asset management can therefore be defined as a strategic and proactive approach to the management of infrastructure, which enables decision-makers to identify when infrastructure investments are needed and to plan for the financial costs necessary to make those investments. The aim of this approach to infrastructure management is to achieve a defined level of service in the most cost effective way possible at all stages of an asset's life. To successfully meet this aim, asset management requires an inherently integrated business approach, involving planning, finance, engineering, and operations personnel to effectively manage infrastructure related activities.

Environmental Benefits of Asset Management

Traditionally, the discussion regarding the benefits realized for asset management has been focused overwhelmingly on its financial, and to some extent social benefits. This conception of asset management, however, is incomplete as it can also result in significant environmental benefits as a review of the literature demonstrates.

Specifically, environmental benefits were noted when asset management principles were applied to existing infrastructure, the procurement of new infrastructure, and 'natural infrastructure', such as watersheds and greenways. The environmental benefits realized

from the practice of asset management included water and energy conservation, and GHG emission reductions. Other environmental benefits included the protection of wildlife and their natural habitats. Similarly, the proper management of natural infrastructure was noted to support the natural regenerative and purification capacities of essential resources such as water.

Empirical Data Methods

In addition to the literature review, this project utilizes two research tasks to accomplish the aims of the project. The first includes a series of expert interviews with local government staff. These interviews identify the extent to which the application of infrastructure asset management principles has resulted in the kinds of environmental benefits that were identified in the literature review. The expert interviews also identify the extent to which asset management is being practiced generally, the key barriers local governments are facing in regards to implementing or maintaining their asset management programs, as well as outlines the suggested recommendations that local government staff provided regarding the implementation of asset management across BC.

This report also relies on data from a survey that was conducted by the Ministry of Community and Rural Development regarding the extent to which asset management is practiced in BC, as well as the challenges local governments are facing in regards to implementing or maintaining an asset management program.

Empirical Data Findings on Environmental Benefits

Overall, the expert interviews found that though many of the environmental benefits outlined in the literature review were being achieved as a result of the application of asset management principles, in the overwhelming majority of instances asset management was being used primarily as a tool for financial sustainability, without consideration of the practice's potential environment benefits.

It was also found that many communities were practicing 'informal asset management', and only for particular classes of assets. Participants noted that only after a comprehensive asset management program was implemented could a community begin to examine the possibility of applying asset management to environmental stewardship. As such, it was determined that supporting communities in implementing a comprehensive, operational, and formalized asset management program would likely be the most significant contribution to promoting the use of asset management as a tool for achieving environmental sustainability by local governments across BC.

Empirical Data Findings on the State of Asset Management in BC

This report also identified the current state of local government infrastructure asset management in BC with the data obtained from the expert interviews as well as the survey. This allowed the researcher to identify the key challenges hindering the implementation or

operation of an asset management program, and identify general recommendations to mitigate these challenges.

Overall, it was found that the majority of communities in BC do not currently have a formalized and operational asset management program in place. The most significant challenges regarding the implementation and operation of an asset management program were found to relate primarily to funding and human resource capacity. Other challenges included a lack of political and public education on the topic, staff knowledge, political will, and inter-departmental cooperation.

Recommendations

To support local governments in implementing and operating a comprehensive asset management program, and to use that program as a tool for environmental sustainability, several general recommendations were made which are listed below.

1. Provincial Guidance:

To assist local governments in identifying and achieving the environmental benefits that result from the application of infrastructure asset management, the Province should develop guidance materials that outline the environmental benefits associated with the practice of asset management.

To assist local governments in the development and operation of an asset management program generally, the provincial government should also consider developing a variety of guidance materials for local government staff, in addition to guidance for newly elected local government officials on the importance of asset management. The guidance materials for staff should focus on how to:

- Secure long-term funding for asset management;
- Gather relevant data, as well as how to put data into a useable format;
- Promote inter-departmental co-operation; and
- Effectively engage the public in order to promote awareness of asset management.

The provincial government should also explore ways in which it could provide resources to communities that address their individual needs, without requiring significant financial expenses on behalf of the local government. This could include a provincially funded consultant, or team of consultants, that the local government could use as an information resource when needed. This would be particularly useful for small and remote communities.

2. Steering Committees

The Province should promote the creation of asset management steering committees within local governments, for the purpose of promoting the inter-departmental collaboration necessary for asset management, as well as to assist communities in identifying and achieving the environmental benefits that result from the application of asset management. Steering committees should include individuals in senior Finance, Engineering, Operations, Administration, Planning, and Environment-related positions.

3. Legislative or Regulatory Change

To ensure that asset management is a priority for local governments across BC, the provincial government should consider requiring that local governments have an asset management plan for all new infrastructure assets that they procure.

4. Public Engagement

The Province should encourage local governments to educate their residents on their community's infrastructure deficit, as well as their community's plan for financial sustainability in regards to infrastructure. This could include a requirement that local governments publish this information annually.

5. Provincial Grants

The Province should consider creating grants targeted to small and remote communities for the purpose of strengthening their human resource and knowledge capacity. Grants could include funding for small, remote communities to hire additional staff members to assist with the implementation and operation of asset management, as well as to fund training opportunities regarding asset management. Grants could also be used to support communities in procuring asset management software, including the costs associated with staff training.

The Province should also consider encouraging the development of reserve funds for existing assets. This could include a fund-matching program, where eligible communities receive a percentage of the amount that they contribute to a reserve fund for existing assets.

6. Additional Funding

The provincial government should encourage communities to establish long-term and secure funding for asset management, where possible. This could include encouraging communities to fund asset management for infrastructure through dedicated utilities, as opposed to general taxation.

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INTRODUCTION AND BACKGROUND

1. Introduction

In modern societies, the services needed for economic and social development are fundamentally supported by infrastructure. Infrastructure allows for water distribution, transportation networks, as well as sewage and waste management. The Canadian Oxford Dictionary defines infrastructure as “the basic structural foundation of a society ... [and is] regarded as a country's economic foundation” (Canadian Oxford Dictionary, 2009; Vanier & Rahman, 2004).

Local governments in British Columbia (BC) have jurisdiction over a significant portion of public infrastructure, including bridges, roads, transit, parks, recreation and cultural facilities, as well as water and wastewater systems, among others. The condition, capacity, and quality of this infrastructure can directly affect the safety, health, and mobility of residents, as well as the economic viability of the community. As such local government decision-makers have the potential to significantly impact the quality of life of residents through the investment decisions they make regarding infrastructure (InfraGuide, 2003b; InfraGuide, 2003c; Vanier & Rahman, 2004).

1.1. Infrastructure Deficit

Many local governments across BC are under pressure to maintain the high quality of the infrastructure related services residents have become accustomed to, increase the efficiency and effectiveness of their infrastructure, and increase their service capacity by expanding existing infrastructure networks. These objectives are complicated by the tight fiscal restraints many local governments are facing, including a growing infrastructure deficit in many BC communities (InfraGuide 2003c; Mizra, 2007).

An infrastructure deficit can be defined as the total additional investment required to repair and prevent deterioration in existing public infrastructure assets, including transit networks, community and recreational facilities, as well as water and wastewater systems (Mizra, 2007). It has been noted in the literature that a significant portion of modern infrastructure in Canada is showing serious signs of ageing and deterioration, and as a result is in urgent need of investment (Halfawy, 2008; Mizra, 2007).

The current local government infrastructure deficit in Canada can be attributed to two primary factors. The first is the unexpected change of provincial and federal regulatory requirements that require local governments to upgrade or renew their infrastructure, even though they lack the financial resources to do so. The second factor is the failure of local governments to properly maintain their infrastructure, as evidenced by the deferral of

infrastructure maintenance and renewal. In many instances this is the result of short-term infrastructure planning that has not taken into account the lifecycle cost necessary for the maintenance, operation, refurbishment, renewal and disposal of infrastructure assets. As a result, local government decision-makers, due to limited revenues, are forced to choose between providing popular services and making necessary investments in infrastructure. The result is often the deferral of infrastructure investment, particularly for 'buried assets' such as pipes and water pumps, which often yield little political capital from financial investment (Conference Board of Canada, 2009; InfraGuide, 2005a).

The failure to maintain infrastructure properly creates escalating costs over the life of an asset. Similarly to a fiscal deficit, a deficit in lifecycle maintenance is subject to compounding costs. For example, the cost of repairing a road crack can increase from \$1 per linear meter for crack filling, to \$15 per meter for resurfacing, to \$45 for rebuilding, within a 5 to 10 year period (Mizra, 2007). In other words, the deferral of necessary investment in infrastructure contributes to a more rapid deterioration of assets, and eventually to escalating costs for local governments. (Danylo & Lemer 1998; Grigg 1999; Halfawy 2004; Halfawy 2008).

Proper infrastructure asset management is the systematic process of planning for the maintenance, renewal, and operational costs, in order to maintain a defined level of service in the most cost effective way possible. In practice, asset management enables local governments to avoid an infrastructure deficit caused by the deferral of necessary investments due to a lack of financial resources. Among other objectives, this paper will identify the current state of local government infrastructure asset management in BC.

1.2. Municipal Environmental Commitment

In addition to the existing infrastructure deficit, environmental degradation and climate change pose serious health, security, and economic threats to British Columbians and the communities in which they live. For this reason, local governments in BC are committed to pursuing environmental sustainability, despite their fiscal constraints.

The commitment of BC's local governments to environmental stewardship has been demonstrated in a number of ways. Most prominently, in September 2007 the BC Government and the Union of BC Municipalities signed the *Climate Action Charter* along with 62 local governments. To date, 175 local governments have signed the Charter, which amounts to 96 percent of all local governments in BC (BC Government & Union of BC Municipalities (UBCM), 2009). In signing the Charter, local governments agreed to the following:

- Measuring and reporting their communities' GHG emissions profile;
- Creating complete, compact, and more energy efficient communities; and
- Being carbon neutral in respect to their operations by 2012 (BC Government & UBCM, 2009; BC Ministry of Community and Rural Development (MCD), 2009).

Local governments across BC have also demonstrated their commitment to environmental sustainability in a number of other ways, such as by adopting aggressive GHG reduction targets. Though recent changes to the *Local Government Act* require local governments to set GHG reduction targets in their Official Community Plans, the extent to which local governments reduce emissions is not stipulated. Several examples of the aggressive targets communities from across BC have chosen to adopt are listed below:

- Dawson Creek has committed to reducing GHG emissions by 33 percent by 2020 and by 85 percent by 2050;
- The Capital Regional District and Metro Vancouver have committed to reducing GHG emissions by 33 percent by 2020, and 80 percent by 2050; and
- The City of North Vancouver has committed to reducing GHG emissions by 80 percent from 2007 levels by 2050, and 100 percent by 2107(BC MCD, 2010).

Additional actions that local governments across BC are taking to promote environmental sustainability include:

- Creating new positions or departments within their organization to promote the integration of climate action planning;
- Developing overarching goals, strategies and actions to promote sustainable community development;
- Integrating climate action policies and actions into Regional Growth Strategies and Official Community Plans;
- Developing educational websites and other community engagement tools, to promote sustainability issues to residents, including those related to water, waste, and transportation;
- Implementing systematic programs to monitor progress; and
- Developing policies to support green settlement patterns, green transportation, local food supply, green buildings, and the preservation of natural resources, among others (BC MCD, 2010).

The large number of local governments that have signed this voluntary Charter, as well as undertaken other substantial actions to promote environmental sustainability signifies the importance that local governments in BC place on environmental stewardship and climate change mitigation in particular. Among other objectives, this paper will identify the ways in which the practice of infrastructure asset management can result in significant environmental benefits for BC communities, and therefore help communities meet their aggressive environmental targets.

1.3. Purpose of Project

Infrastructure asset management at the local government level has been widely promoted in the literature as a necessary practice to ensure the fiscal sustainability of local governments, and to protect the quality of life, health, and safety of residents. However, the environmental benefits resulting from the practice of infrastructure asset management have been understudied, and the extent to which local governments in BC are practicing asset management is currently unknown.

This report has two primary objectives. The first is to identify the environmental benefits of implementing infrastructure asset management principles at the local government level. This will provide an environmental rationale for the use of a basic asset management program, in addition to the financial and social reasons that have been widely discussed in the literature. The identification of the environmental benefits of infrastructure asset management will also allow the Province to promote asset management to local governments as a way to support their current commitment to environmental stewardship, which was noted above. The second key objective of this report is to identify the state of asset management in BC, including the extent to which asset management is used as a tool to meet municipal environmental objectives. This report will also provide recommendations to the Province to further support the use of asset management as a tool for environmental sustainability.

This report consists of two main parts. First, a literature review is used to explore the environmental benefits realized from the use of asset management. Specifically, the literature review will include a discussion of the environmental benefits realized when key asset management principles are applied to existing, new, and natural infrastructure. The literature review will also provide a short discussion of the additional environmental benefits realized when environmental considerations are explicitly integrated into a basic asset management program.

Second, this report will rely on a survey and expert interviews to identify the state of asset management in BC, as well as the extent to which asset management is being used to meet environmental objectives. This section will add to the findings identified in the literature review, and will contribute to the state of knowledge regarding the environmental benefits of asset management. This section will also reveal the common barriers hindering the implementation of an asset management program at the local government level, and a series of recommendations will be provided to the Province to support the practice of asset management as an environmental tool.

Table 1. Research Objectives and Methods

Research Objectives	Methods
Identify the environmental benefits of asset management	Literature Review, Expert Interviews
Identify the state of asset management in BC	Survey, Expert Interviews
Identify the extent to which asset management is used in BC as a tool to achieve environmental benefits	Expert Interviews

2. Asset Management Overview

A variety of definitions exist for infrastructure asset management in the literature. At its core, asset management is a strategic and proactive approach to the management of infrastructure, which enables decision-makers to identify when infrastructure investments are needed and to plan for the financial costs necessary to make those investments (National Asset Management Steering (NAMS) Group, 2002; Vanier & Rahman, 2004). In other words, asset management takes a long-term view of infrastructure costs and performance, allowing municipalities to identify “the right strategy for the right asset at the right time” (U.S. Department of Transportation, 2010). The aim of this approach to infrastructure management is to achieve a defined level of service in the most cost effective way possible at all stages of an asset’s life. To successfully meet this aim, asset management requires an inherently integrated business approach, involving planning, finance, engineering, operations and other practices to effectively manage infrastructure related activities (Department for Victorian Communities, 2004; NAMS Group, 2002).

2.1. Key Principles of Asset Management

Asset management programs vary in their scope and complexity, depending on the extent of the local government’s existing infrastructure, the projected future needs of the community, and the human resources, fiscal and information systems capacity of the local government (Institute of Public Works Engineering Australia, 2000). Nevertheless, several key principles can be identified as core components of infrastructure asset management.

In a review of the literature, the following key principles of asset management have been identified:

- Recognizing that a local government’s infrastructure is a valuable asset;
- Taking a lifecycle approach to infrastructure management;
- Managing assets in an integrated way that makes use of interdepartmental collaboration, and an interdisciplinary management approach to optimize investment decisions;
- Defining a level of service within the context of a community’s goals;
- Conducting future impact evaluation and risk management of asset failures;
- Identifying, valuing and assessing the condition of existing assets; and
- Planning for the future maintenance, refurbishment, replacement, disposal and procurement costs of infrastructure assets (Conference Board of Canada, 2009; InfraGuide, 2005a; NAMS Group, 2002; Sinha, Iseley & Whittle, 2005; US EPA, 2002).

A significant amount of literature exists that provides guidance on the integration of these principles into specific policies, strategies, and plans. This report, however, will focus on the environmental benefits realized when asset management principles are practiced generally.

2.2. The Practice of Asset Management

In many respects, the practice of infrastructure asset management is what public works personnel have been doing for centuries (Vanier & Rahman, 2004). There is disagreement in the literature on the origin of the comprehensive practice of asset management outlined in the section above, however most authors note that it began to be practiced between 15 and 35 years ago (InfraGuide, 2005a; McNeil, Tischer, & DeBlasio, 2000; Vainer & Rahman, 2004). The following section outlines a number of significant national, provincial, and international initiatives related to the current practice of infrastructure asset management.

2.2.1. Canadian Initiatives

The Canadian Public Sector Accounting Board (PSAB) recently made changes to the requirements for reporting on tangible capital assets (TCA). These changes are widely noted to support the implementation and practice of infrastructure asset management. Specifically, the new PSAB regulations (PSAB 3150), which came into force in January 2009, require that municipalities report on all TCAs on an accrual basis, as opposed to the traditional method of reporting TCAs as capital expenditures only when assets are created or replaced. In addition, local governments will also be required to provide regular assessments of the condition and life expectancy of all infrastructure assets being tracked (Fowler, 2007; Sparks & Christensen, 2007). It is important to note that PSAB 3150 does not require local governments to practice asset management. However, the changes to PSAB 3150 are intended, in part, as a first step to support the practice of asset management, as the information collected can be used to drive asset management planning and decision-making. (Ontario Ministry of Municipal Affairs and Housing, 2010; Sparks & Christensen, 2007).

Canada is recognized as a leader in forming multi-disciplinary groups to promote the use of asset management in local governments across the country. The National Round Table on Sustainable Infrastructure, and The National Asset Management Working Group, which are made-up of planners, engineers, accountants, academics, and local government elected officials, are two examples of this approach (Félio, 2006). These groups, along with others, generate and disseminate knowledge regarding asset management (InfraGuide, 2005a).

At the provincial level few standards have been implemented to support local government asset management. Ontario, which is recognized as a Canadian leader in this regard, passed the *Sustainability Water and Sewage Systems Act* in 2002, which requires local governments to assess and report on the actual costs of providing sewage and water services, and to develop plans for recovering those costs (InfraGuide, 2005a). This supports the practice of asset management as it requires the consideration of the lifecycle costs of water and sewage utilities, and requires local governments to have the necessary funds needed to provide related services.

British Columbia, which is also recognized as a Canadian leader in asset management, has established the Local Government Asset Management Working Group of BC, which, like its national counterpart, promotes the practice of asset management to local governments.

This group is sponsored by the BC Ministry of Community and Rural Development, and includes multi-disciplinary participants from local governments across BC.

In addition, most provinces have developed guidance to assist local governments in implementing the new national PSAB requirements regarding tangible capital assets (InfraGuide, 2005a, Ontario Ministry of Municipal Affairs and Housing, 2010).

2.2.2. International Initiatives

Australia and New Zealand are widely recognized in the literature as the front-runners in infrastructure asset management best practices (Félio, 2006; Urquhart, 2006; Infrastructure Canada, 2006). In 1993 the Australian Accounting Standards Board issued Standard 27, which required local governments to account for their TCAs; this is similar to the new Canadian accounting requirements regarding TCAs (PSAB 3150). Both standards are widely recognized as supporting the practice of asset management (InfraGuide, 2005a). In New Zealand, the *Local Government Act* of 2000 requires local governments to develop and implement asset management plans (Félio, 2006).

In addition to these long-standing standards, the New Zealand National Asset Management Steering Group and the Institute of Public Works Engineering Australia created the National Asset Management committee to support asset management activities (Infrastructure Canada, 2006). Beginning in 1995, this committee published the first edition of the *International Infrastructure Management Manual*, which provides guidance to local governments regarding the development and implementation of an asset management plan, including how to complete an inventory of assets, conduct a condition assessment, and prioritize infrastructure investments (Félio, 2006; Infrastructure Canada, 2006; Vanier & Rahman, 2004).

2.3. Benefits of Asset Management

The rationale for adopting an infrastructure asset management program has overwhelmingly been focused on the fiscal, and to some extent the social, benefits of asset management, both of which are widely discussed in the literature (InfraGuide, 2005a; NAMS Group, 2002).

Fundamentally, asset management supports fiscal sustainability as it eliminates a primary cause of municipal infrastructure deficits: short term decision-making that does not plan for the future financial costs of operating, maintaining, refurbishing, and renewing infrastructure assets. In contrast, asset management requires that decisions be made with consideration to the lifecycle costs of infrastructure related investments, as securing the funding of those future costs is a primary aim of asset management. The practice of asset management has also been noted to extend the useful life of infrastructure assets, which reduces costs associated with refurbishment and renewal. Specifically, an asset management program requires that infrastructure is maintained to the extent that the

defined service level is achieved. This avoids the more rapid deterioration of assets, and the compounding of costs, which was discussed above (Conference Board of Canada, 2009; Félio, 2006; InfraGuide, 2005a; NAMS Group, 2002; Sinha, Iseley & Whittle, 2005; US EPA, 2002).

With regard to social benefits, asset management is noted to assist in the management of risk associated with asset failure, allow for improved and more consistent levels of service, and increase the transparency and accountability of infrastructure management (InfraGuide, 2005a; NAMS Group, 2002).

The traditional discussion regarding the benefits realized from asset management however is incomplete, as the use of asset management also results in significant environmental benefits. This component of asset management has been rarely discussed in the literature or in asset management guidance documents, and has rarely been pursued by asset management working groups. However, an understanding of the environmental benefits of asset management may be particularly useful for local governments in BC, given their commitment to environmental sustainability, which was noted above. The following section will include a review of the available literature, for the purpose of exploring the ways in which the practice of asset management supports environmental stewardship at the local government level.

LITERATURE REVIEW

1. Section Overview

The aim of this literature review is to identify the environmental benefits resulting from the practice of asset management at the local government level. As was noted above, the vast majority of literature on infrastructure asset management at the local government level focuses on the fiscal and social benefits of asset management, as well as product reviews of available asset management data systems, and development and implementation guidance for asset management policies, strategies, and plans. There is also a large portion of the related literature that discusses the ways in which environmental considerations can be integrated into an asset management program, and the resulting environmental benefits of that integration. As such, the following literature review draws on the available literature where the environmental benefits of implementing a basic asset management plan have been discussed or alluded to, even though the focus of the articles cited was often not the identification of the environmental benefits of asset management.

In particular, this literature review will explore how the practice of asset management supports environmental stewardship in relation to three types of infrastructure related decisions. These three areas include:

- The planning for future operations, maintenance, and refurbishment costs of existing assets;
- The procurement and renewal of infrastructure assets; and
- The application of asset management principles to the management of ‘natural infrastructure’ assets, such as watersheds and greenways.

This review of the available literature will also briefly identify the ways in which a basic asset management plan can be strengthened to become a central tool for local governments to achieve their environmental goals.

2. The Management of Existing Infrastructure Assets

The practice of asset management includes planning for the future costs associated with the maintenance, operation, refurbishment and renewal of existing infrastructure. This requires the identification of infrastructure assets, the assessment of their condition, as well as the development of a systematic process to prioritize infrastructure related investment. It also requires the earmarking of revenue to cover the future costs needed for investment. This approach allows municipalities to avoid ‘crisis infrastructure management,’ and instead plan for the investments necessary to maintain the level of service that residents expect in the most cost-effective and efficient way possible.

This section will demonstrate that the practice of asset management results in environmental benefits from the increased efficiency of infrastructure, the extended life of infrastructure, the consideration of risks associated with asset failure, the ability to accurately price infrastructure related services, the use of an integrated approach in managing infrastructure, and the defining of a community’s expected service levels. A summary of the environmental benefits discussed in this section is provided in the table below.

Table 2. Environmental Benefits of Managing Existing Infrastructure

Asset Management for Existing Infrastructure Results in:	Environmental Benefits:
Improved Efficiency	<ul style="list-style-type: none"> • Water Conservation • Energy Conservation • Reduction of GHG Emissions
Increased Capacity and Extended Life	<ul style="list-style-type: none"> • Reduction in Embodied Energy • Reduction in Waste • Reduction of GHG Emissions
Risk Management	<ul style="list-style-type: none"> • Avoided Environmental Degradation Associated with Asset Failure
Integrated and Interdisciplinary Approaches	<ul style="list-style-type: none"> • Reduction in GHG Emissions and Energy Associated with Rework • Reduction in Embodied Energy
Defined Service Levels	<ul style="list-style-type: none"> • Water Conservation • Energy Conservation • Reduction in GHG Emissions
Accurate Pricing of Municipal Services	<ul style="list-style-type: none"> • Water Conservation • Energy Conservation

2.1. Improved Efficiency

The practice of infrastructure asset management ensures that the conditions of a local government’s infrastructure assets are routinely assessed, and that those assets are receiving investments as needed. This has been noted in the literature to contribute to the increased energy and water efficiency of infrastructure, as it allows infrastructure managers to detect inefficiencies, such as leaks, and make the necessary investments to repair those inefficiencies. This has been noted to result in a reduction in GHG emissions, as well as in water and energy conservation (Brandes, Mass & Reynolds, 2006; Conference Board of Canada, 2009; Sahely, Kennedy, & Adams, 2005).

The clearest example of this benefit is in relation to water distribution infrastructure. Specifically, water leaks have been noted to result in significant water loss for communities. Some studies have noted that up to 13% of municipal water is unaccounted for (Brandes, Maas & Reynolds, 2006). This is in part due to the leak detection methods used by many local governments. In communities where asset management is not practiced, there is often only ‘passive detection’ of infrastructure inefficiencies. In other words, leaks are discovered

only when property is damaged or when water reaches the surface (Brandes, Maas & Reynolds, 2006; Sahely, Kennedy, & Adams, 2005). Asset management, on the other hand, requires the continual assessment of infrastructure so that communities can accurately prioritize their infrastructure investments, ensuring that the defined level of service is being provided in the most cost-effective way possible.

The increased infrastructure efficiently from the practice of asset management results in significant long-term financial benefits. The literature noted that fixing water leaks “easily results in 5% to 10% water savings ... [and] upwards of 30% in systems with older infrastructure” (Brandes, Maas & Reynolds, 2006, 6). Leaks have also been noted to allow water to enter sewer networks, which negatively effects performance and adds to operation costs for stormwater and waste systems. Finally, detecting and repairing leaks minimizes the need for future infrastructure expansions, as it maximizes the efficiency of the existing infrastructure (Brandes, Maas & Reynolds, 2006; Sahely, Kennedy, & Adams, 2005). For example, the Halifax Regional Water Commission was able to reduce water leaks by 27 million litres of water per day by implementing an aggressive monitoring system to detect leaks. This action resulted in annual cost savings of over \$500,000 (Brandes, Maas & Reynolds, 2006).

The repair of inefficiencies, such as water main leaks, has several positive environmental benefits in addition to the financial benefits of reducing operations costs, and the social benefits of improving the performance of the system and level of service to the customers. The repair of water leaks reduces the total amount of water expended. This decreases the pressure placed on water sources, as it reduces the risk of overburdening the watershed and the associated negative impacts on habitat and recharge. In addition, increasing the efficiency of infrastructure reduces the amount of energy consumed, and the associated GHG emissions of that energy use. California has noted the significance of these energy savings, as water related energy - including deliver, storage, and treatment - consumes approximately 20% of the electricity of the State. (Brandes, Maas & Reynolds, 2006; Sahely, Kennedy, & Adams, 2005).

2.2. Increased Capacity & Extended Useful Life

Infrastructure asset management requires the anticipation of asset degradation and breakdown so that the necessary investments can be made to maintain the defined level of service, extend the life of that infrastructure, and increase the infrastructure’s capacity without expansion (Félio & Potkins, 2000). This has been noted to lead to significant long-term financial infrastructure cost reductions, as well as considerable environmental benefits.

The detection and repair of infrastructure inefficiencies increases the capacity of the infrastructure system, which in turn reduces the need for facility expansions (Conference Board of Canada, 2009). The US Environmental Protection Agency has also noted this, stating that new infrastructure construction or expansions can be delayed or eliminated through increasing the efficiency of infrastructure systems, as increasing efficiency reduces

the strain on existing infrastructure (Nelson, 2008). Furthermore, the failure to provide infrastructure assets with the maintenance they require results in the degradation of those assets. As was noted in the introduction section, this significantly reduces the useful life of infrastructure assets, and as such is cited as a key financial reason to adopt the practice of infrastructure asset management (Mizra, 2007).

The environmental benefits of increased infrastructure, and of extending the useful life of existing infrastructure, primarily include the avoided environmental impacts connected with the development of new built infrastructure, including the embodied energy associated with that development (Pullen, 1999; Nathman, McNeil, & Van Dam, 2009). Specifically, in each stage of an infrastructure's lifecycle there is energy used for raw material extraction, material production, construction processes, and the transportation of materials. Embodied energy is defined as the energy that was used throughout the lifecycle of a product. As such, reducing the need for infrastructure expansion or procurement reduces the local government's consumption of the embodied energy in the procurement or expansion of infrastructure, along with the GHG emissions associated with the embodied energy (Nathman, McNeil, & Van Dam, 2009).

Assets with longer useful lives have also been noted to reduce waste, as the frequency at which materials are scrapped will be reduced (InfraGuide, 2003b; Sinha, Iseley, & Whittle, 2005). It is also important to note that options regarding the disposal of infrastructure may also be greater for local governments that practice asset management. As asset management takes a lifecycle approach to infrastructure management, the cost of disposal of the asset will also be taken into account before infrastructure is acquired. This may lead infrastructure managers to choose assets that have a greater salvage value, or are able to be recycled, both of which reduce waste (Department of Victorian Communities, 2004).

2.3. Risk Management

All infrastructure assets are exposed to considerable risks, including natural events such as floods, external impacts such as power supply failures, as well as structural failures like breaks or collapses. (Department for Victorian Communities, 2004; Sinha, Iseley & Whittle, 2005). As was noted in the Introduction section of this paper, risk management is a key component of infrastructure asset management, and requires the identification of 'risk exposure', which includes the likelihood and consequence of asset failure. This allows for infrastructure investment to be prioritized on the basis of risk, providing the ability to distinguish between emergency and remedial action. It is important to note that local governments that lack the capacity to determine the probability of asset failure can prioritize infrastructure investments based on the consequences associated with asset failure alone (Department for Victorian Communities, 2004; Félio & Potkins, 2000; InfraGuide, 2003c; Marlow & Burn, 2009; Nelson, 2008; Sinha, Iseley, & Whittle, 2005). This practice has been noted to have considerable financial and environmental benefits.

The US Environmental Protection Agency (EPA) has noted that asset management programs integrate the consideration of environmental risk because of the potential for

large financial gains (Nelson, 2008). In the context of environmental impacts, this is largely due to the remedial expenditures that are avoided by investing in infrastructure before it fails. The US EPA noted that large cost savings of up to 20% were realized from this approach (Nelson, 2008). Canada's National Guide to Sustainable Infrastructure also notes that investments in risk mitigation that protect environmental functions and services eliminates or reduces economic costs, as it avoids remedial expenditures, such as fish habitat enhancement, and the like (InfraGuide, 2003c).

The environmental benefits realized from the integration of risk management principles present in an asset management program are also primarily related to avoided environmental degradation. Sinha, Iseley & Whittle (2005) note that the practice of asset management "can provide fast and reliable decision-making tools that are needed to handle the large volume of deteriorating buried municipal pipeline infrastructure systems ... that pose serious threats to the environment if they fail" (p. 1). Examples in the literature have primarily focused on the environmental degradation relating to the failure of sewage treatment plants (InfraGuide 2003c; Marlow & Burn, 2009; Department for Victorian Communities, 2004). In Ottawa, for example, heavy rain can overburden the sewage treatment infrastructure, as the city shares a combined sanitary and storm sewage system. This results in raw sewage being flushed into the Ottawa River, causing bacterial contamination which forces the closure of beaches and impacts the wildlife and plant species that depend on the waterway (CBC News, 2008).

2.4. Accurate Pricing of Municipal Services

The current infrastructure deficit is in part due to the under pricing of municipal infrastructure-related services, as the current price charged to consumers for many municipal services is not reflective of the lifecycle costs of the infrastructure needed to provide those services. Adopting an asset management program can enable infrastructure managers to become aware of the extent of this disparity, as asset management requires the consideration of the lifecycle costs of existing infrastructure assets. Asset management also provides a strong incentive for accurately pricing infrastructure related services, as it requires earmarking revenues for future infrastructure related expenditures. A commitment to environmental stewardship also provides a strong incentive for accurately pricing infrastructure services, as it was noted to result in significant environmental benefits as it decreases demand, which limits its impact on natural resources.

Water provides an important example of the impact of the under pricing of infrastructure-related services. The literature noted that water prices in Canada are the lowest in the industrial world. On average, households pay 0.02 to 0.06 cents per litre of water, which is less than half the price that consumers pay in most OECD countries. This price only covers half of the financial cost required to supply water and treat wastewater (Brandes, 2005; Ringskag, 2000). Pricing structure also has important implications for water consumption. The two main types of pricing structures are volume-based and flat-rate (Brandes, 2005). Flat-rate is the most common pricing structure used in Canada by local governments. With this pricing structure, a fixed rate is charged to consumers regardless of the volume of

water that is consumed. Local governments have tended to prefer this pricing structure, because of the simplicity it provides in terms of billing, and the consistency it provides in terms of revenues. With a volume-based pricing structure, the price of water is based on the volume of water consumed (Brandes, 2005; O'Connor, 2002; Reynaud & Renzetti, 2004).

Low prices and a fixed-rate pricing structure result in perverse economic incentives that promote excessive water use and waste (Ringskag, 2000). This is largely due to the perception that water is 'free' (Vander Ploeg, 2004). Environment Canada noted that 74% more water is consumed per day in households where a flat-rate pricing structure is used, when compared to a volume-based pricing structure (Brandes, Maas & Reynolds, 2006). Excessive water consumption was noted to decrease water infrastructure efficiency and lead to significantly increased infrastructure costs. Specifically, high water use requires increased maintenance and may require infrastructure expansion or the development of new infrastructure because of artificial demand (Brandes, 2005; O'Connor, 2002; Brandes, Maas & Reynolds, 2006).

From an environmental perspective, prices are one of the most effective ways to promote the conservation of scarce resources (Conference Board of Canada, 2009). In regards to water, it was noted in the literature that increasing the price of water could result in water savings of over 20% (Brandes, Maas & Reynolds, 2006). There are several significant environmental benefits realized as a result of water conservation. Brandes (2005) notes that high water use can alter the hydrological cycle, which can degrade water quality, damage stream habitat, reduce biodiversity, and impair ecological functions and services, among other impacts. Environmental impacts associated with the embodied energy from the expansion or development of new infrastructure are also avoided if demand is reduced (Conference Board of Canada, 2009).

2.5. Integrated and Interdisciplinary Approach

As discussed in the introduction section, asset management is an inherently integrated and interdisciplinary approach to the management of infrastructure. Currently, communities that do not practice asset management typically manage their infrastructure with little consideration to the relationship between various categories of assets. This failure has been noted to result in inefficiencies and negative environmental impacts in the maintenance coordination and renewal planning of existing infrastructure (Halfawy, 2008; InfraGuide, 2005).

Considering the relationship between co-located infrastructure, for example, has been noted to reduce rework, disruption, risks associated with maintenance, and costs (Halfawy, 2008). A clear example of this includes the connection between roadwork and buried infrastructure. If the relationship between assets is considered, it is likely that buried assets will be assessed while roadwork is ongoing. This is in contrast to a 'silo approach' in which local government departments work independently from one another. The literature noted that a 'silo approach' may result in roads, for example, having to be dug up before the

end of their useful life to perform maintenance on the buried assets underneath them, as opposed to performing maintenance on the buried assets at the same time the roads are under construction (Love, Edwards, Watson & Davis, 2010). The environmental benefits of considering the relationship between co-located infrastructure include the avoided GHG and energy related impacts from rework, and embodied energy associated with the use of additional materials (Halfawy, 2008).

2.6. Establishing Service Levels

The aim of an infrastructure asset management program is to provide the established level of service in the most cost effective way possible (Department for Victorian Communities, 2004). As such, the establishment of objective and measurable service levels for each asset is needed. Service levels are defined in the *International Infrastructure Management Manual* as “...defined service quality for an activity of service area (for example, the Road Network) against which service performance may be measured” (NAMS Group, 2002, p. 8). Service levels relate primarily to the following measures: quantity, quality, capacity, safety, aesthetics, reliability, responsiveness, costs, and environmental acceptability, among others (Department for Victorian Communities, 2004). The established service level for each asset serves as the basis for future infrastructure investment, and therefore is needed to determine the lifecycle costs of existing infrastructure. In other words, without a defined level of service, one cannot determine the lifecycle costs of the infrastructure, as different levels of services will require different levels of investment (InfraGuide, 2003a). The identification of service levels can lead to significant environmental and financial benefits, particularly if used in conjunction with demand management (InfraGuide, 2004a).

The traditional approach to increased demand for sewage treatment, parkland, water, and road space has been to increase the level of service, at large costs to the local government (Curran & Leung, 2000). Asset management, through the requirement to define service levels, may result in a local government opting to reduce service expenditures by decreasing demand through demand management. A demand management approach assumes that demand for services is not a fixed quality, but rather that it is influenced by perceptions of affordability, sustainability, convenience, availability, and the like. A demand management program may include an information campaign, caps on service, along with various incentives and disincentives. The literature noted that most local governments engage in some form of demand management, such as water conservation in peak periods or ‘bag limits’ for solid waste services, to reduce infrastructure costs associated with demand for high service levels (Brandes, 2005; FCM, 2004; InfraGuide, 2004a; Vander Ploeg, 2004).

Water, energy, transportation, and solid waste services can realize long-term financial benefits from the practice of demand management, primarily because it eliminates the need for the expansion or reconstruction of infrastructure to meet high service level demands (Brandes, 2005; FCM, 2004). Curran and Leung (2000) noted that it costs significantly less in the long-term to control the demand for water, than to build additional reservoirs. It was also noted that communities experience savings in operations and

maintenance costs (CMHC, 1999; FCM, 2004). In regards to water, Brooks & Rouse (2003) suggest, “in almost every sector, cost effective savings of 20% to 50% of water use are readily available” from demand reductions (p. 9).

The environmental benefits resulting from the practice of demand management are significant. Reducing average water demand and wastewater flow, for example, can protect groundwater supplies, which may help to maintain the flow in streams and wetlands (CMHC, 1999). Environmental impacts associated with the embodied energy from the expansion or development of new infrastructure, are also avoided if demand is reduced (Conference Board of Canada, 2009).

3. The Procurement of New Infrastructure Assets

Infrastructure asset management requires that a local government plan for the lifecycle costs of infrastructure, including the maintenance, operations, refurbishment, renewal, and disposal costs of infrastructure assets. The purpose of this is to ensure that a defined level of services is continually provided in the most cost effective way possible, while avoiding the negative impacts of deferred maintenance and the entrenchment of an infrastructure deficit. For a community that is practicing asset management then, the procurement of infrastructure assets should be based on ‘whole life value’, with consideration given to long-term costs and risk, including environmental risks (Too, Bettes & Arun, 2009). As such, the practice of asset management may result in local governments acquiring infrastructure that is initially more expensive, yet has lower lifecycle costs, as it requires less maintenance, has a longer service life, or has a lower risk of failure.

Similarly, a local government practicing asset management may determine that new infrastructure should not be procured at all because of lifecycle financial implications (Conference Board of Canada, 2009). For instance, a community may receive government grant funding to purchase new infrastructure, such as a community recreation centre. An asset management approach requires that this new asset be considered a liability, as the local government will need to earmark funding for future operations and maintenance costs. As such, a local government that practices asset management may determine that even an initially ‘free’ asset, such as one paid for through grant funding, may be too costly because of the future expenditures that will be required to continue to provide a particular level of service. To highlight this point, the City of Hamilton (2001) found that construction expenses for civic buildings amounted to only 8% of the building’s total costs over a 30-40 year time period, while operation and maintenance expense amounted to 92% of the building’s total costs.

The literature noted that the type of infrastructure that is purchased and the location of that infrastructure can have significant implications on long-term infrastructure costs, and can also have significant environmental implications (Conference Board of Canada, 2009; InfraGuide, 2003c). This section will explore the ways in which infrastructure design, resource recovery, and compact land use decisions are aligned with an asset management

approach, and also the ways in which they can result in significant environmental benefits for communities. It is important to note that there is a wealth of literature on infrastructure design, resource recovery and land use. As such, this section will only provide a general discussion on how the use of asset management principles would likely result in a local government opting for this practice, and the environmental benefits associated with that choice.

3.1. Infrastructure Type

As was noted above, improving the efficiency of existing infrastructure assets can yield significant financial and environmental benefits through actions such as reducing leaks. In a similar way, significant financial and environmental benefits can be realized from acquiring more efficient infrastructure that not only reduces the energy or water that is used, but also allows for opportunities to extract value from waste, such as sewage.

3.1.1. Infrastructure Design

In regards to infrastructure design, significant cost savings and environmental benefits can be realized from acquiring infrastructure that is designed to be efficient in terms of water and energy use. The Federation of Canadian Municipalities (2004) has noted that “there is growing evidence that strategies and technologies supportive of sustainability are possible, relevant and provide services at lower costs and even at lower capital investments than conventional approaches” (p. 3). This applies to infrastructure systems, as well as recreation and community infrastructure facilities, such as arenas or community halls (Kats et al., 2003; Nelson, 2008).

The literature notes that though costs are initially higher for energy efficient buildings and infrastructure, in the long-term local governments can realize significant cost savings. Specifically, it was found that a 2% increase in initial costs for energy efficient buildings and other infrastructure results on average in 20% lifecycle saving of the total construction costs (Kats et al., 2003). This also results in the environmental benefits associated with reduced energy use, and the associated GHG emissions.

Infrastructure design that makes use of passive functions can also result in significant financial and environmental benefits. The Federation of Canadian Municipalities (2004) notes that, “by increasing infrastructure reliance on passive functions such as gravity, geothermal energy, or sunlight and wind, we virtually make use of free services from nature without exploiting non-renewable systems” (p. 6). An example of this may include designing municipal buildings to take full advantage of sunlight, which reduces the need for artificial lighting and to some extent heating, resulting in the financial and environmental benefits associated with energy reduction.

The fixtures installed in local government buildings can also result in water and energy conservation. Installing efficient toilets and faucets, for example, allows for the provision of

the same level of service while consuming less water and energy. The literature noted that efficient appliance and fixtures can result in water savings of 33% to 50% (Brandes, Maas & Reynolds, 2006; FCM, 2004).

3.1.2. Resource Recovery

Integrated Resource Recovery (IRR) is an approach to thinking about waste, and in particular the possibility for reclamation, reuse, and recycling of resources that are extracted from waste. IRR is based on the principle that infrastructure should be designed to emulate the closed-loop cycle present in nature. Specifically, in nature there is no waste, as all outputs provide sources of energy and resources for the ecosystem, and therefore are continually recycled (BC MCD, 2009; Brandes, Maas & Reynolds, 2006; O'Riordan, Lucey, Barraclough, & Corps, 2008). The following table, which was adapted from the BC Government's guidance document on IRR, identifies the ways in which 'waste' can be used as a resource within an IRR approach.

Table 3. Comparison of Conventional Waste Management and Resource Recovery

Waste Product/Resource:	Conventional Approach:	IRR Approach:
Storm Water	Collect and discharge into receiving environment	<ul style="list-style-type: none"> • Collect, treat, and reuse on-site; • Divert to ecological uses; • Reduce amount of impermeable surfaces through water sensitive urban design; and • Follow natural drainage and hydrology
Waste Water	Collect, treat, and discharge into receiving environment	<ul style="list-style-type: none"> • Collect, treat, and reuse water for regulator-approved non-portable purposes
Biosolids	Collect and landfill, or apply to industrial landscaping	<ul style="list-style-type: none"> • Collect and divert to composting or anaerobic digestion to produce biomethane; and • Recover nutrients through regulator-approved use of residuals
Wet Organic Waste (e.g. food waste)	Collect and landfill	<ul style="list-style-type: none"> • Collect and divert to composting or anaerobic digestion to produce biomethane; and • Recover nutrients through regulatory-approved use of residuals

Dry Organic Waste (e.g. yard waste, non-recyclable paper)	Collect and landfill	<ul style="list-style-type: none"> • Collect and divert to composting or to energy production; and • Recover nutrients through regulator-approved use of residuals
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(BC MCD, 2009, 7).

Resource recovery has been noted to result in significant financial savings, as well as environmental benefits associated with water and energy conservation and the reduction of GHG emissions. It is important to note, however, that these benefits are varied depending on the type of project that is undertaken (BC MCD, 2009; Brandes, Maas & Reynolds, 2006; O’Riodan, Lucey, Barraclough, & Corps, 2008).

In terms of infrastructure costs, IRR is noted in the literature to potentially provide a new source of revenue for communities, which can then be used to offset infrastructure costs. For some projects, IRR has also been noted to reduce the need for new or expanded infrastructure, as it can reduce the required capacity. The reduction in required capacity has also been linked to reduced lifecycle costs relating to operations and maintenance (BC MCD, 2009; Vickers, 2001). The environmental benefits of IRR are also significant, and varied. In general, these include: reduction of GHG emissions, provision of carbon neutral forms of energy, water and energy conservation, reduction in the development of new or expanded infrastructure, and reduction of water pollution, among others. (O’Riodan, Lucey, Barraclough, & Corps, 2008; BC MCD, 2009; FCM, 2004).

Municipal water provides a clear example of the ways in which IRR can lead to financial and environmental benefits for a community. Currently all local government water is treated to drinking water standards, even though the vast majority of it is used for purposes that do not require that level of treatment. Specifically, a BC-based study noted that only 5% of indoor residential water is used for drinking and cooking purposes (Brandes, Maas & Reynolds, 2006). As such, reclaimed greywater is a vastly underutilized resource. Greywater is defined as wastewater produced from dishwashing, laundry, bathing and other similar domestic activities, as opposed to blackwater, which contains human waste. Reclaimed greywater can be directed to irrigate non-food crops, irrigate parks and residential laws, as well as to flush toilets (Brandes, Maas & Reynolds, 2006; FCM, 2004). This type of action was noted to potentially result in water savings of up to 50% (Brandes, Maas & Reynolds, 2006, 31).

Rainwater harvesting provides another clear example of the ways in which IRR can lead to financial and environmental benefits for a community. An Australian study found that harvesting rainwater in dry regions delayed infrastructure expansion by 28 to 100 years, which equated to savings of over \$47 million in the Central Coast region and \$48 million in the Lower Hunter area. In wetter climates, such as Brisbane and Sydney, even greater water savings were realized (Coombes & Kuczera, 2003). In these examples the rainwater

was used for outdoor watering, in addition to toilet flushing, laundry, and hot water. The environmental benefits of rainwater harvesting have also been noted to include: reducing environmental impacts associated with decreased demands on water sources, reduced erosion and flooding associated with high rainfall, and reduced energy and associated GHG emissions due to the reduced amount of water discharge into municipal sewers for transportation and treatment (Brandes, Maas & Reynolds, 2006; O'Riordan, Lucey, Barraclough, & Corps, 2008).

3.2. Land Use Planning

Sprawl is defined in the literature as development that is characterized by the conversion of agricultural and natural land to low-density suburbs, business areas, or commercial centers, which are separated from one another by roads and parking lots (Mizra, 2003; Vander Ploeg, 2004). This type of development has significant financial and environmental implications, which have been widely discussed; these include increased maintenance costs for infrastructure and services, as well as increased GHG emissions, among others. The consideration of asset management principles before new infrastructure is procured can have significant impacts on the way in which land is used, which in turn can have significant financial and environmental benefits. Specifically, as asset management requires the consideration of lifecycle costs, high-density growth is encouraged because it results in lower operations and maintenance costs over the long-term.

The realization that sprawl can result in significantly higher lifecycle costs for a municipality's infrastructure has encouraged a number of municipalities in BC to instead pursue smart growth strategies, which focus on developing compact and complete communities. Compact communities are those in which there is an efficient use of land, which includes higher density, mixed land uses (residential, workplace, and commercial spaces located within one neighbourhood), close proximity to transit, and walkable neighbourhoods (BC Government, 2010). Complete communities are defined as those that provide a variety of jobs, housing, local services, recreation, and schools, so that people's needs for daily living can be met without requiring residents to leave the community (BC Government, 2010).

Much literature exists on how sprawl can significantly increase the costs of infrastructure (Vander Ploeg, 2004). The table below outlines some of the data found in the literature regarding the costs associated with sprawl. The primary cause is attributed to the larger geographical areas that a local government is then required to service. For instance, compact development allows for shorter water transmission systems, which makes the system less susceptible to water leaks, and more efficient to operate. Furthermore, if new developments are able to make use of existing infrastructure, it avoids the costs and associated environmental impacts of expansion and new construction (Brandes, Maas & Reynolds, 2006; Blais, 1996; Benedict & McMahon, 2002).

Table 4. Financial Benefits of Smart Growth

Local Government Infrastructure	Financial Benefits of Smart Growth
Overall Impact	<ul style="list-style-type: none"> • A study of land and infrastructure needs for the Central Okanagan over the next forty years found conventional low-density residential development would require 20,645 acres and cost \$1.57 billion to service. More compact development would reduce land needs by half and cost \$1.04 billion to service (Ramlo, 2000). • The literature noted that scattered development can be as much as 70% more costly than equivalent forms of compact development (Ducan et al, 1989).
Water and Wastewater	<ul style="list-style-type: none"> • The Regional District of Nanaimo found that when compact development and green building design was practiced operating costs associated with water and wastewater was reduced from \$19 million to \$9 million, over a 20-year period. When green building design was completed without compact development, operations costs associated with water and wastewater were reduced from \$19 million to \$10 million (Sheltair Group, 2008). • Studies found that for roads, water, and sewers, compact development is 45% less expensive than leapfrog, far-out development (Frank, 1989). • A US study found that utilities, such as water, sewer, storm drainage cost 58% less to build and 30% less to maintain in a neighbourhood of townhouses than in one of single-family conventional houses (Slack, 2002).
Roads and Transit	<ul style="list-style-type: none"> • The literature noted that transit is viable with higher densities. In Sechelt it was found that transit in low density areas it can cost as much as \$4 -\$7 per ride, increasing to \$13 per ride in the evening (Sustainable Solutions Group, 2007). • The literature noted that efficient public transit requires densities of 20 to 30 units per hectare (Smart Growth BC). • A study on the impacts of rural sprawl found that road maintenance costs per year were approximately \$62 for a 5 acre lot, \$35 for a 0.1 acre lot, and \$16 for a 0.07 acre lot (Buchan, 2001). • A US study estimates that road and street systems cost 33% less to build and 51% less to maintain in a neighbourhood of townhouses than in one of single-family conventional houses (Slack, 2002).

Smart growth results in significant gains in terms of water and energy conservation and the reduction of greenhouse gas emissions. In the literature it was noted that over half of the GHG emissions in BC are attributed to the way cities are laid out; impacts related to additional personal vehicle transportation were noted to be the primary contributor to sprawl-related emissions (Alexander & Tomalty, 2001). Similarly, in an international study it was noted that gasoline consumption was directly related to urban density, with lower density cities having the highest gasoline consumption rates (Alexander & Tomalty, 2001; Newman & Kenworthy, 1989). Sprawl has also been noted to have other negative environmental impacts including a loss of biodiversity and habitat, as well as degradation of watershed health (Brandes, Maas & Reynolds, 2006). Some of the GHG related benefits noted in the literature as resulting from smart growth are included in the table below.

Table 5. Environmental Benefits of Smart Growth

Local Government Sectors	Environmental Benefits of Smart Growth
Overall Impact	<ul style="list-style-type: none"> • North Vancouver found that by simply changing the kinds and locations of urban development, the City could achieve a per capita energy reduction of 31% (City of North Vancouver, 2007). • Salt Spring Island found that GHG emissions were 22% lower when new development occurred near a village and 7% lower when it occurred in hamlets, when compared to the baseline (Sustainable Solutions Group, 2007). • The Sierra Club has noted that infrastructure needs arising from sprawling development produces approximately 8 more tons of CO₂ emissions per household per year (Sierra Club, 2007).
Transportation	<ul style="list-style-type: none"> • The Regional District of Nanaimo found that when compact development was practiced there was a 26% reduction in GHG emissions associated with transportation over 20 years, when compared to business as usual (Sheltair Group, 2008). • Salt Spring Island found that GHG emissions from road construction were reduced by 26% when new dwellings were built in hamlets or in the village, when compared to the baseline (Sustainable Solutions Group, 2007). • A study on the District Sechelt noted that compact development would result in a 23% reduction of GHG emissions associated with transportation, as there would be an increase in walking and public transit, and a decrease in the kilometres traveled by private vehicles (Dill, 2009). • In a Kitsilano- and Langley-based study, transportation emissions in a compact, complete neighbourhood were found to be 60% less than those of a dispersed neighbourhood (CMHC, 2000).

Solid Waste	<ul style="list-style-type: none"> The Regional District of Nanaimo found that when compact development and green building design was practiced there was a 52% reduction in GHG emissions associated with solid waste over 20 years, when compared to business as usual, due to increased composting and solid waste credits. When green building design was practiced without compact development there was only a 39% reduction in GHG emissions associated with solid waste, when compared to the baseline (Sheltair Group, 2008).
Community Energy Supply	<ul style="list-style-type: none"> Natural Resources Canada has noted that a combined heat and power plant with biomass as its fuel source would be feasible at a minimum density of 55 units per hectare. Biomass fuel is considered to be carbon neutral (Sustainable Solutions Group, 2007).

4. The Management of Natural Infrastructure Assets

So far, this literature review has explored the ways in which asset management principles can result in environmental benefits when applied to existing and new ‘built infrastructure.’ However, it is important to note that asset management principles can also result in significant environmental benefits when applied to a local government’s ‘natural infrastructure.’

The term ‘infrastructure’ is usually used to refer to water distribution systems, sewers, roads, and other built structures; however, municipalities are increasingly expanding their definition of infrastructure to include watersheds, trees, green spaces, natural habitat areas, streams and waterways, and the like (Nelson, 2008). For the purpose of this literature review, this type of infrastructure will be referred to as natural infrastructure, though it is important to note that in the literature it is also referred to as ‘green infrastructure’ or indirectly as ‘ecosystem management’ (Curran & Leung, 2000; Nelson, 2008).

The practice of asset management supports the promotion of development that safeguards natural infrastructure and the important environmental functions and services it can provide. Specifically, asset management requires that local governments recognize that infrastructure should be viewed as valuable assets. Therefore, since natural infrastructure provides many important services similar to built infrastructure, an asset management approach should also apply the same principles to natural infrastructure (Nelson, 2008). Furthermore, the protection of natural infrastructure is aligned with the principles of asset management as it improves the quality and capacity of infrastructure related services, and as it significantly reduces lifecycle infrastructure costs (Curran & Leung, 2000; InfraGuide, 2003c). This section will explore the negative implications of traditional infrastructure

development, as well as some of the financial and environmental benefits derived from protecting and managing natural infrastructure.

4.1. Implications of Traditional Development

Traditionally development has often failed to consider the impacts of development on the functions and services of natural infrastructure. Curran and Leung (2000) note that this has resulted in a “ditch it” and “pave it” approach to development that has focused on removing environmental functions and services, as opposed to investing in and managing those functions and services to capitalize on their financial and environmental benefits (p.17). The rapid expansion of suburban areas, or sprawl, has been noted in the literature to significantly contribute to this outcome, as the natural environment is reduced or degraded, along with the functions and services it provides (Alexander & Tomalty, 2001; Brandes, Maas & Reynolds, 2006).

Furthermore, the traditional use of natural resources has not taken into consideration environmental carrying capacity. Rather, it is often assumed that the natural environment can sustain the changes made to it (InfraGuide, 2003b; Wakernagel and Reese, 1996; Brandes, 2005). This can have serious implications on natural infrastructure, such as the ability of aquifers to recharge, which can mitigate droughts, or the ability of rivers to maintain their hydraulic cycles, which is essential for their continued ability to support ecological diversity (Brandes, Maas & Reynolds, 2006). One US study noted that significant ecological changes could occur when as little as 15% of a watershed is built over (Curran & Leung, 2000). Deforestation can have similar negative impacts, as it may inhibit natural recharge and reduce water supply quality (Brandes, 2005).

4.2. Benefits of Natural Infrastructure Asset Management

Natural infrastructure assets provide a number of important ecological functions and services. These include storm water management, habitat protection, flood control, water and air quality improvement, groundwater capture, maintenance of natural landscape processes, as well as water storage and assimilation (Benedict & McMahon, 2002; Curran & Leung, 2000; InfraGuide, 2003c). These functions and services have important environmental benefits as they provide habitats for a diverse set of wildlife and plant species, absorb pollution such as carbon, and filter out toxins in essential resources like water (Benedict & McMahon, 2002).

In addition to providing important ecological and environmental benefits, a number of these natural functions and services can also result in decreased infrastructure costs for local governments if they are protected and managed well. For instance, new development has been noted to decrease surface water quality and therefore impact the cleanliness of water. This may result in a local government needing to find an alternative water supply sources or upgrade their water treatment facilities (DeBarry, 2004; InfraGuide, 2003c; Sinha, Iseley & Whittle, 2005; US EPA, 1995). Protecting open spaces, trees, and plants can

also limit the impact of storms, as they absorb rain and storm water, reducing the need for storm sewers. This ‘natural infrastructure’ has also been noted to filter and clean water before it is absorbed into the ground, which is then used to recharge surface and ground water (Curran & Leung, 2000).

There are also costs associated with the increased likelihood of risk if natural infrastructure systems are not protected. For instance, replacing threatened flood plain properties with greenways has been noted to significantly reduce the need for flood relief and repair efforts. Similarly, the storm water management and pollution filtration services natural infrastructure provides have been noted to decrease the risk of floods and environmental degradation, which also decreases the costs associated with remediation and relief efforts (Benedict & McMahon, 2002). The following table, which was adapted from Brandes’ (2005) article on ecological governance, provides a number of examples of the environmental functions and services that natural infrastructure can provide, if protected and managed well.

Table 6. The Functions and Services of Natural Infrastructure

Environmental Function or Service	Environmental Benefit
Flood mitigation	Functionally intact freshwater systems buffer stormwater flows, reducing flood damage
Drought mitigation	Functionally intact freshwater systems absorb rainwater, slow runoff and help recharge groundwater
Maintenance of natural landscape processes	Freshwater flows maintain the salinity gradients that are critical to the biological diversity and productivity of deltas and coastal marine environments
Enriched habitat and biodiversity	Rivers, streams, floodplains, wetlands, riparian areas, and forests provide habitat and breeding sites for numerous aquatic, avian and terrestrial species
Sink services	Healthy ecological systems possess an ability to absorb and neutralize pollution
Purification	Wetlands filter and break down pollutants, enhancing water quality
Soil fertility maintenance	Functional river-floodplain systems constantly renew the fertility of surrounding soils
Land subsidence prevention	Groundwater stored in aquifers prevents land subsidence and reduces erosion through absorption of runoff

(Brandes, 2005, 3).

5. The Integration of Environmental Considerations into Asset Management

This literature review has demonstrated that the practice of asset management supports environmental stewardship at the local government level. This has been noted in regards to the maintenance and repair of existing assets, the procurement of new assets, and the management of natural infrastructure assets. It is also important to note, however, that though a basic asset management approach does lead to environmental benefits, the literature emphasized that the integration of environmental considerations into an asset management program, particularly through the valuation of environmental impacts, yields significantly greater environmental benefits (InfraGuide, 2003b). Furthermore, it has been noted that municipalities are increasingly integrating environmental considerations into their long-term planning processes (InfraGuide, 2005b; Marlow & Burn, 2009).

It has been argued in the literature that the inclusion of negative externalities in decision-making analyses is necessary for the development of asset management programs that are aligned with the principles of sustainable development (Marlow 2008a; Marlow & Burn, 2009). One of several terms that have been used in the literature for this practice is 'environmental accounting', which is the practice of incorporating the environmental costs and benefits into an accounting system (InfraGuide 2003b).

A negative externality is a detrimental or negative impact on an outside party that has occurred as a result of a financial transaction, where the affected party is not compensated for the impact and where the cost of that impact is not factored into the price of the product. This can lead to perverse economic incentives, as the price of the product does not reflect all of the 'costs' involved in the product's production. This results in the under pricing of products, and therefore the overconsumption of products as the lower prices increase consumer demand. Pollution serves as an example of a potential negative externality, as the environmental degradation resulting from production (such as GHG emissions) is often not factored into the cost of a product. If pollution were factored into the cost of the product, then consumers would have an incentive to purchase products that produce less pollution. Marlow and Burn note that the exclusion of negative externalities results in "market forces ... favour[ing] resource use and over-use, rather than resource conservation and environmental protection" (p. 21).

The valuation of environmental impacts, and the inclusion of those impacts into the lifecycle costs of local government infrastructure would orient infrastructure decision-making towards environmental sustainability (InfraGuide, 2003c). For example, if a new sewage treatment plant was noted to produce an excessive amount of carbon emissions, it may be determined to be too 'costly' if environmental impacts are monetized and added to the lifecycle costs of the asset; whereas without the addition of environmental impacts, the treatment plant may be chosen as the preferred option because its financial lifecycle costs are less than more energy efficient options.

6. Literature Review Conclusion

The purpose of this literature review was to identify the ways in which a local government may experience environmental benefits from the practice of infrastructure asset management. To meet this aim, this literature review has described how the practice of asset management can incur environmental benefits across all types of infrastructure, be they existing, newly procured, or natural infrastructure. This review has also demonstrated how environmental benefits could result from the explicit integration of environmental impacts into local government decision-making analyses, as is demonstrated in environmental accounting.

The environmental benefits realized from the practice of asset management included water and energy conservation, and associated reduction in GHG emissions. Other environmental benefits included the protection of wildlife and their natural habitats. Similarly, the proper management of natural infrastructure was noted to support the natural regenerative and purification capacities of essential resources such as water.

The following section will rely on a survey and a series of expert interviews with local government staff to identify the state of asset management in BC, and the extent to which asset management is currently being used by local governments to meet their environmental objectives.

EMPIRICAL DATA AND RECOMMENDATIONS

1. Methodology

The aim of this project is to identify the environmental benefits of implementing infrastructure asset management at the local government level, for the purpose of further promoting asset management as a best practice for communities in BC. This project also aims to add to the available literature by identifying the extent to which local governments in BC are currently practicing infrastructure asset management, as well as the extent to which asset management is currently being used as a tool to meet environmental objectives. These findings are used to develop recommendations to support the further integration of this practice into the decision-making processes of local governments across BC.

In addition to the literature review, this project utilizes two primary research tasks to accomplish the aims of the project. The first includes a series of expert interviews with local government staff. These interviews identify the extent to which the application of infrastructure asset management principles has resulted in the kind of environmental benefits that were identified in the literature review. The expert interviews also add to the available literature by identifying the extent to which asset management is being practiced in BC as a tool for environmental sustainability. The interviews also explore the extent to which asset management is practiced generally in BC, and the key barriers BC local governments are facing in regards to implementing or maintaining their asset management programs.

This report also relies on data from a survey that was conducted by the Ministry of Community and Rural Development (MCD) regarding the extent to which asset management is practiced in BC, as well as the challenges local governments are facing in regards to implementing or maintaining an asset management program. The following subsections describe the methodologies for both of these research tasks.

Table 7. Research Objectives and Methods

Research Objectives	Methods
Identify the environmental benefits of asset management	Literature Review, Expert Interviews
Identify the state of asset management in BC	Survey, Expert Interviews
Identify the extent to which asset management is used in BC as a tool to achieve environmental benefits	Expert Interviews

1.1. Expert Interviews

1.1.1. Method

Expert interviews were used to gather information on the state of infrastructure asset management, as well as the environmental benefits realized from the practice of asset management for several reasons. Interviews allowed the researcher the flexibility to further explain the questions presented to the participants, as well as provided the researcher the opportunity to ask follow-up questions. This was thought to be important, as it was assumed that some of the participants might not be familiar with the potential environmental benefits realized from infrastructure asset management, all of the terms presented in the questions, and all of the principles of asset management generally.

Interviews also allowed the researcher to clarify participants' responses and to further explore responses when needed. Specifically, it was assumed that communities would identify a wide variety of challenges in regards to asset management given the diversity of populations, government structures, and geographical distribution of local governments in BC. As such it was felt that interviews would be more informative in regards to identifying this variety, as opposed to creating a survey in which local governments would select their responses.

1.1.2. Participant Selection

The target population for the expert interviews included individuals from local governments across BC in senior administrative, engineering, operations, finance, planning, and environmental sustainability-related positions. These individuals were targeted because of their likelihood to have in-depth knowledge about their community's asset management program, and the environmental benefits being realized from the practice of asset management.

To identify potential participants, the researcher first identified a list of eligible communities for the purpose of ensuring that a representative sample was selected. To meet this aim the researcher chose communities of varying population sizes, with different government structures, and with a wide geographical distribution. The researcher also reviewed Official Community Plans, and well as other online materials from communities across the province to help ensure that communities were selected with varying experience with asset management.

Potential participants were first contacted by email or telephone, and were provided with an overview of the project. It was then determined if the individual contacted was the most appropriate person to interview at their local government, and if so, if they were willing to participate in the project. If a potential interviewee agreed to participate, they were emailed the consent form along with a more detailed overview of the themes that would be addressed in the interview. Interviews occurred after a signed consent form was returned to the researcher. A copy of the consent form used can be found in Appendix A.

1.1.3. Response Rate

In total, participants from 35 communities were contacted by telephone or email requesting participation in the project. Appendix B includes the recruitment email that was sent to potential participants. Follow-up phone calls were made to communities that did not respond to the initial invitation. In total, individuals from 15 communities were interviewed. It is important to note that though this response rate is low, the researcher was able to obtain a good representation of communities by size.

Several potential participants declined to be interviewed because of recent staffing changes in their communities, which left the remaining staff with an increased workload, or a deficit in knowledge regarding asset management. Potential participants from a few other communities declined to be interviewed as they did not have an asset management program or because they did not feel they would be able to identify any environmental benefits from the practice of asset management. Despite the researcher's reassurance that all responses would be confidential, and that input from communities without an asset management program or where environmental benefits were not being realized was welcomed, some potential interviewees still declined to participate. In the majority of instances, however, there was no reason given for not participating, as individuals simply did not respond to the email or telephone messages.

It is also important to note that no individuals in environmental sustainability-related positions agreed to participate, referring the researcher instead to individuals in finance or engineering positions. The reason given was that the individuals in environmental sustainability-related positions lacked knowledge of their community's asset management program and the potential environmental benefits that may result from that program. The two charts below outline the employment position of each of the 15 interviewees, as well as the population of the communities interviewed.

Table 8. Employment Position of Interview Participants

Local Government Staff Position	Number of Participants
Administration	4
Finance	4
Engineering & Operations	5
Asset Management	2
Environmental Sustainability Managers/ Coordinators	0

Table 9. Community Population of Interview Participants

Community Population	Number of Participants
5000 and less	4
5001 – 15000	3
15001-50000	3
50001 and greater	5

1.1.4. Interview Questions

The interview questions were focused around five overarching themes. Within each theme several questions were prepared to begin the discussion or further prompt interviewees if needed. Interview participants were sent a list of the five themes, along with some explanatory material before the interview, so that they could prepare. The information that was sent to participants can be found in Appendix C.

The first four themes, and the associated questions (outlined in Table 10), were designed to inquire about additional environmental benefits resulting from asset management that were not identified in the literature review. In addition, the questions were designed to add to the available literature to determine the extent to which local governments in BC are currently using asset management as a tool for environmental sustainability. For example, the literature review found that various environmental benefits resulted when asset management principles were applied to the management of existing infrastructure, the procurement of new infrastructure, and the management of natural infrastructure. As such, the interview participants were asked what environmental benefits their communities had realized when asset management principles were applied to these three areas. Participants were also asked what general environmental benefits their community had realized from the practice of asset management.

The remaining two themes, and the associated questions were chosen to assess the current state of asset management in BC communities, as well as the barriers local governments are facing in this regard. This was deemed to be important because without a functioning asset management program, communities would be less likely to realize the environmental benefits associated with the implementation of asset management principles. In addition to inquiring about the existence of a formalized asset management program, the interview also included questions regarding the Public Sector Accounting Board’s requirement (PSAB 3150) that local governments account for and amortize all of their tangible capital assets. This was included as the literature indicates that the process of valuing infrastructure assets is widely recognized as the first step to developing an asset management program (Fowler, 2008; Ontario Ministry of Municipal Affairs and Housing, 2010; Sparks & Christensen, 2007). The six overarching themes, and their associated questions are presented in the chart below.

Table 10. Interview Themes and Questions

Interview Themes	Questions
Overall environmental benefits	<ul style="list-style-type: none"> • Has your community realized any environmental benefits from the practice of asset management?
Environmental benefits realized from managing existing infrastructure	<ul style="list-style-type: none"> • Does your community’s asset management plan encompass the management of existing infrastructure assets? If not, outside of daily operations costs, does the community plan for the costs associated with the maintenance and renewal of its existing infrastructure? • In what way do you see these actions as resulting in environmental benefits? • Are you currently tracking these environmental benefits? • Are these actions explicitly recognized by the local government to be supporting environmental stewardship?
Environmental benefits realized from purchasing new infrastructure when asset management principles are applied.	<ul style="list-style-type: none"> • Does your asset management plan encompass the procurement of new infrastructure? If not, does the community incorporate lifecycle costs into decisions regarding the procurement or renewal of infrastructure? • In what way do you see these actions as resulting in environmental benefits? • Are you currently tracking these environmental benefits? • Are these actions explicitly recognized by the local government to be supporting environmental stewardship?
Environmental benefits from the management of natural infrastructure.	<ul style="list-style-type: none"> • Does your community’s asset management plan encompass the management of natural assets? If not, how does the community manage its natural infrastructure? • In what way do you see these actions as resulting in environmental benefits? • Are you currently tracking these environmental benefits? • Are these actions explicitly recognized by the local government to be supporting environmental stewardship?
The state of infrastructure asset management in the community.	<ul style="list-style-type: none"> • Does your community currently have an asset management program that is formalized, in place, and operational? Please describe. • Is your community currently compliant with the PSAB 3150 requirements? If so, does your local government exceed the PSAB 3150 requirements in regards to asset management? • Will your community be building on the data gathering and analysis needed for PSAB 3150 to develop an asset management program? • Does your community have a medium to long-term vision for asset management? If so, please describe.

Barriers local governments are facing with respect to implementing and maintaining an asset management program	<ul style="list-style-type: none"> • What organizational, technical, or other barriers does your municipality face with respect to implementing and maintaining an asset management program? • What can be done to help your municipality overcome these barriers?
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1.1.5. Interview Limitations

There are several limitations in regards to the interview data that are important to highlight. First of all, it is likely that communities with a more advanced asset management program, or a stronger understanding of asset management principles responded to the solicitation for participation for this project. This was demonstrated as several communities declined to participate due to their lack of knowledge of asset management. Though efforts were made to control for this by reviewing Official Community Plans (OCP) and reviewing online material to help ensure that those selected for an interview were representative of communities across the province, it was difficult to accurately determine the experience a local government had with asset management from OCPs and other online material. Specifically, the majority of communities did not have a formalized asset management program, and as such it was not discussed in online material or in OCPs. As a result of these factors, the interview result may portray a more favorable outlook in terms of the state of asset management than is actually the case.

The interview results are also limited in that the researcher only interviewed one individual from each of the 15 communities that participated. Though individuals holding a variety of positions participated in the interviews, limiting the participation to one individual per community likely provides a limited perspective on each individual community. This is due in part because asset management requires an inherently integrated approach, involving planning, finance, engineering, operations and other practices to effectively manage infrastructure related activities.

In addition, the individual that participated may not have had a strong understanding of environmental sustainability, as in most cases the researcher was referred to individuals in finance and engineering positions. Though the researcher tried to include individuals in positions related to the environment and sustainable development, it is important to note that every individual contacted in such a position declined to participate in the interview given their lack of knowledge of asset management.

Finally, it is important to note that the interview findings cannot be generalized with statistical accuracy. However, it is assumed that the closer the results of the interview are to the findings of the literature review, as well as the survey conducted by the Ministry of Community and Rural Development (MCD), the more confidence it will provide to researchers when making assumptions beyond the sample.

1.2. Asset Management Survey

1.2.1. Method

The provincial government, in conjunction with the federal government, established the Municipal Rural Infrastructure Fund (MIRF) in 2006 for the purpose of improving municipal and rural infrastructure. The grant funding was administered in BC by the MCD, and was awarded to local governments between 2006 and 2007 for projects with a completion date before March 2010. For BC communities that met the eligibility requirements, a further condition for receiving funding was established by the Ministry. This included the completion of an Asset Management Survey which identified the current and intended future use of asset management approaches, and demonstrated how the recipient of the grant funding would be responsible for the maintenance, use, and performance of the new infrastructure over the long-term. The Ministry requested that the researcher analyze the findings of this survey to identify the state of infrastructure asset management in BC.

This survey is particularly useful as it utilizes both quantitative and qualitative questions. The quantitative questions provide a snapshot of the state of asset management within the communities surveyed. The qualitative questions allow participants to describe the key challenges they are facing, as well as provide recommendations regarding asset management. A copy of the survey given to participants can be found in Appendix D.

1.2.2. Participant Selection and Response Rate

As was mentioned above, the survey was a condition of receiving MRIF grant funding and as such only communities that were awarded funding were asked to complete the survey. The survey was targeted to individuals in senior finance, planning, and engineering positions. However, it is important to note that the Ministry requested that individuals completing the survey do so in conjunction with staff in other positions to ensure that the information provided was accurate and complete.

To ensure participation, the Ministry reserved the right to withhold payment of the final grant claim until the recipient of the grant had completed and submitted the updated electronic Asset Management Survey requirements. As a result, all of the 31 recipients of the grant funding completed the Ministry's Asset Management Survey. Furthermore, all of the questions relied upon in this report were answered by all of the survey respondents.

1.2.3. Survey Questions

The survey was built into an MS Excel document and included various quantitative and qualitative questions, some of which were relevant to the second key objective of this report: to identify the state of asset management in BC. Specifically, the survey asked the respondent to:

- Identify if their community has a formalized asset management strategy, or if their community intends to implement one.
- Describe the current state of knowledge regarding the inventory, location, condition, age, book value and residual life of the existing infrastructure for the applicable system.
- Identify any software application that is used to manage attribute information (i.e. GIS, capital maintenance management system).
- Highlight any current policies, procedures or plans that support asset management
- Describe any future or current initiatives that are underway which will improve asset management.
- Describe how maintenance and replacement is linked with the local government's overall long-term financial strategy .
- Outline how asset management is being used to support and satisfy the Public Sector Accounting Board's reporting requirements for tangible capital assets.
- Provide recommendations for improvements to asset management programs.

It is important to note that not all of the information collected by the Ministry's asset management survey was relevant for this report. As such, this report only utilized questions focusing on the state of asset management, and recommendations for improvements to asset management programs. This was deemed to be important because without a functioning asset management program, local governments are less likely to achieve the environmental benefits associated with the implementation of asset management principles, which were highlighted in the literature review.

1.2.4. Survey Limitations

There are several limitations in regards to the survey data that are important to highlight. First of all, the survey is limited in that only communities that received the MRIF grant were included in the survey. To be eligible for this grant, communities had to have a population of less than 250,000, and as a result, the largest cities in the province were excluded from the survey. Furthermore, to be eligible for the grant, communities had to demonstrate that they could afford to own, operate, and maintain the infrastructure in their application. As a result, communities that were successful in their application had the capacity to put together a business case demonstrating the long-term financial management of their new infrastructure. Therefore, communities that received the grant funding, and completed the survey, may have had a greater capacity for asset management than may be the case in the province as a whole.

The survey is also limited in that almost all of the qualitative answers provided by respondents are short, with little detail or context provided. As a result, the qualitative responses provided add little to the findings of this report.

Finally, it is important to note that the results of this survey cannot be generalized with statistical accuracy because of the way in which participants were selected. That being said, the closer the results are to the interviews and other research studies, the more confidence it will provide to researchers when making assumptions beyond the sample.

2. Empirical Data Part A: Environmental Benefits

The empirical data is presented in two parts. The first, which includes this section, explores the environmental benefits that local governments have realized as a result of the implementation of asset management principles. The second empirical data section will explore the state of infrastructure asset management in BC. Each section will present the relevant findings from the expert interviews and survey, as well as provide a discussion of those findings.

2.1. Findings

Presented below are the expert interview findings regarding the environmental benefits realized from the practice of asset management. All of the interview responses were compiled and then analyzed to identify the main themes common to local governments across BC. The findings are organized by the key themes that were used to structure the literature review and interview questions.

2.1.1. Environmental Benefits of Managing Existing Infrastructure

Interview participants were asked several questions regarding the environmental benefits realized from the application of asset management principles to the management of existing infrastructure. The researcher first asked participants about any general environmental benefits their community had realized, and then asked if some of the specific benefits identified in the literature review had been realized in the participant's individual community. It is important to note that several of the participants stated that the interview was the first time that they had realized the environmental benefits associated with asset management.

Risk Management

Almost all of the participants noted that the inclusion of risk management in the management of their community's infrastructure resulted in the most significant environmental benefits. Specifically it was noted that this practice resulted in avoided environmental degradation. Several communities noted, by way of example, that risk management helped ensure that water mains and sewer mains did not overflow into the natural environment, which would lead to significant environmental degradation. It is also important to note that in communities where asset management was not formally practiced, risk aversion was the most commonly cited potential environmental benefit from the adoption of an asset management program.

Additional Environmental Benefits

Participants from larger communities (populations greater than 15,000) with a functioning and operational asset management system noted several additional environmental benefits from the practice of asset management. This included environmental benefits resulting from reduced roadwork, as well as from the increased capacity and useful life of their assets. One participant noted that without infrastructure asset management there would be a higher incident of water main breaks, which would release chlorinated water into fish-bearing streams.

It is important to note that though participants stated that their asset management programs had resulted in environmental benefits, these benefits were not being explicitly recognized in any of the communities' asset management or sustainability plans. Rather, asset management, when applied to existing infrastructure, was described as being used exclusively as a tool for achieving financial sustainability. Environmental benefits that resulted from the practice of asset management were seen as "bonuses." This was underscored as participants indicated that their communities did not track the environmental benefits realized from the practice of asset management in relation to existing infrastructure. Several participants noted that the existence of "silos" within their organization hindered their community's ability to recognize the environmental benefits of infrastructure management.

Participants from communities with and without a formalized and operational asset management program also cited several environmental initiatives that the literature review showed to be connected to asset management principles. The clearest example of this was in regards to reducing water consumption. Specifically, several participants noted that their communities were practicing demand management, which included rebate programs to encourage the procurement of low flush toilets, the installation of water meters, changing pricing mechanisms to discourage consumption, as well as public awareness campaigns. Several other environmental initiatives resulting in infrastructure cost savings were also mentioned by participants, such as streetlight dimming programs and initiatives relating to the co-generation of electricity on gravity flow water mains. In most instances participants noted that these were primarily environmental initiatives. As such, even though these projects also resulted in reduced infrastructure costs, they were excluded from the community's infrastructure management plan. In one instance a participant noted, "No environmental benefits are being realized from asset management." However, when asked about general environmental initiatives that the community has undertaken, the participant cited numerous actions that also had resulted in infrastructure cost savings. Several participants noted that they were engaging in these types of environmental initiatives because "it was the right thing to do," regardless of the impact these initiatives had on long-term infrastructure costs.

This was not the case in every community, however. Several participants from smaller communities (population under 15,000) noted several initiatives that were aimed at reducing the cost of infrastructure and providing various environmental benefits. Smaller communities noted that due to the small size of their organizations, the increased

communication between departments enhanced their ability for the infrastructure management team to work closely with planners and environmental sustainability coordinators. However, initiatives aimed at reducing the cost of infrastructure while providing environmental benefits were undertaken on a project-by-project basis, and were not systematically part of the way in which the communities managed their existing infrastructure.

Barriers

It is also important to note that a significant number of communities had yet to adopt a fully functioning asset management program, and that this was cited as a key barrier to the realization of environmental benefits for existing infrastructure. Specifically, some of the environmental benefits noted in the literature review were not occurring in some communities because they lacked a functioning asset management program. For example, one community did not have an integrated approach to infrastructure management and as such was not achieving the environmental benefits associated with managing co-located infrastructure, which was discussed in the literature review above. A number of participants noted that once their asset management program is fully operational they would explore any potential connection the practice of asset management might have in contributing to environmental sustainability. However, participants also noted that their first priority was being compliant with the PSAB 3150 requirements.

2.1.2. Environmental Benefits of Procuring New Infrastructure

Interview participants were asked several questions regarding the environmental benefits realized from the application of asset management principles to the procurement of new infrastructure.

Infrastructure Lifecycle Costs

The overwhelming majority of participants noted that lifecycle costs are not systematically considered when new infrastructure is procured. Rather, many participants noted that there is an “informal” consideration of lifecycle costs. A number of participants described it as an “intuitive” part of the job. That being said, several participants, particularly those from small communities (population less than 5,000), noted that initial costs are often the primary consideration.

There were, however, a few exceptions to this. Several of the participants from larger communities (population greater than 50,000) noted that their local government specifies the type of product allowed to be procured for particular classes of assets, even though those assets may not be included in the community’s asset management program. Pipes serve as one example of this, as does pavement gradation. The participants noted that in these instances, the type of product chosen by the community is based on the products’

compatibility with the overall system, as well as the estimated service life of the product. Participants from these communities noted that the environmental benefits realized from the consideration of lifecycle costs were not tracked and were not explicitly recognized by the community. Rather, lifecycle costs were considered exclusively for financial reasons.

Innovative Infrastructure

In regards to infrastructure type, several participants noted that to reduce infrastructure costs their local governments were beginning to procure new types of infrastructure, such as energy efficient pumps and motors, which have the environmental benefit of reducing energy consumption and GHG emissions. Several participants from larger communities (population greater than 15,000), where an asset management system is operational, noted that these decisions were emerging from the application of their asset management program.

One participant, for example, noted that her community is studying the possibility of power generators in storm sewers, as this would allow for the generation of electricity, and in turn would produce enough revenue to pay the associated energy costs for pumping. Another participant from a large community with an established asset management program noted that as result of an asset management approach, his community is beginning to use narrower roads to cut down on future maintenance. The environmental benefits associated with less embodied energy needed to construct and refurbish the road, as well as the reduced environmental impacts associated with clearing land to pave the road were also cited by the participant.

Communities without an asset management program were also engaging in similar initiatives. One participant, for example, noted that his community was currently considering procuring a new sewage treatment plan, which would be geothermal and gravity powered, resulting in significant energy and capital savings. Participants from such communities, however, noted that these investments were being made on a project-by-project basis and that the environmental benefits did not explicitly arise from the application of asset management principles.

Land-Use

Several participants noted that their communities are beginning to take proactive action in regards to land use planning. A few of the participants cited initiatives to reduce sprawl for both environmental and infrastructure-cost related reasons, however land use planning was in no instance integrated into an asset management program or seen as resulting from an asset management program. Other participants noted that the reduction of sprawl was a component of their community's official plan for the primary reason of reducing infrastructure costs.

One participant, for example, noted that her community is looking at land use as a way to cut down on road infrastructure. However it was noted that this initiative was done for primarily infrastructure cost-saving reasons, and any environmental benefit has not been explicitly recognized in the community's sustainability plan. Another participant noted that his community is beginning to require developers to include infrastructure services in the design of new developments when those developments are not near existing infrastructure networks. In regards to sewage treatment, this requires the developer to ensure that secondary treatment can happen on the site and off the grid, which reduces the associated financial and environmental impacts associated with infrastructure expansion.

2.1.3. Environmental Benefits of Managing Natural Infrastructure

Interview participants were asked several questions regarding the environmental benefits realized from the application of asset management principles to the management of 'natural infrastructure.' For the purposes of this report, natural infrastructure includes components of the natural environment, such as watersheds and greenways, which can provide a variety of infrastructure-related functions and services for a community.

Storm Water Management

The majority of communities interviewed recognized the functions and services that the natural environment can provide. Several participants noted that their communities were engaging in some initiatives regarding the protection and management of natural functions and services. Of the initiatives mentioned, the management of storm water was by far the most common. Even for communities that did not have a current storm water plan in place, many noted that they were currently developing one, or intended to do so. One participant noted that her community has a storm water management plan which included the protection of a detention pond. She also noted that this has resulted in decreased infrastructure costs and various environmental benefits.

In addition to storm water management, a few communities noted that the management of their natural infrastructure included the protection of their green space or watersheds through the use of Development Permit Area Guidelines. However, with the exception of storm water management, those communities noted that these initiatives were undertaken for primarily environmental reasons.

Inclusion in an Asset Management Program

It is important to note that almost all of the interview participants stated that the management of natural infrastructure was not a component of their community's asset management program. The failure to include natural infrastructure in an asset management program was attributed to the fact that many of the communities interviewed had yet to formalize an asset management program, or because the asset management

program they do have only encompasses particular classes of assets, such as pavement. Furthermore, several participants noted that the management of natural infrastructure was seen as a “secondary consideration” to the management of built infrastructure, due to “tight fiscal constraints” and the need for large investments in existing built infrastructure.

With the exception of storm water management, several noted that natural functions and services were being considered “informally.” One participant noted that his community had resisted logging near their drinking water source to limit the degradation of that source. Other participants noted that they did not consider the management of natural infrastructure, as their communities do not have jurisdiction over much land.

It is important to note that several participants stated that they hoped that future asset management programs would include natural infrastructure in addition to built infrastructure. One participant said that in the future his community’s asset management plans “should include natural infrastructure, so that the functions and services it provides can be protected and maintained, in addition to protecting the intrinsic value associated with the natural environment.”

2.2. Discussion

This section will analyze the findings presented above, and compare those findings with the information presented in the literature review, for the purpose of informing the recommendations made in the final section of this report.

2.2.1. Comparison with Literature Review

The expert interviews demonstrate that communities are observing environmental benefits as a result of the application of infrastructure asset management principles. Appendix E outlines the kinds of environmental actions related to asset management that are currently being practiced in the communities that participated.

Almost all of the potential environmental benefits identified in the literature review as resulting from the application of asset management principles were noted by at least one of the participants. However in the vast majority of cases participants noted that their communities were not making the link between environmental sustainability and financial sustainability in regards to infrastructure. The environmental benefits noted in Appendix E were either not being tracked, or were completed for exclusively environmental reasons, and as such were not perceived to be part of the communities’ asset management program. As noted in the findings above, there were exceptions to this, as several communities did engage in projects aimed at reducing infrastructure costs while achieving environmental benefits, however this was largely done on a project-by-project basis. This indicates that by and large asset management, where it is being practiced, is being used as a tool to achieve financial sustainability in regards to infrastructure, and it is largely not being used as a tool to achieve environmental sustainability.

2.2.2. Guidance Documents

The expert interviews also indicated that participants are interested in the potential for asset management to produce environmental benefits, and that by and large they would like to be provided with more information to support them in making this connection in the future. The need for additional guidance in this regard was also supported by the literature review, which found that virtually all of the available guidance and information on asset management was focused on the financial benefits resulting from this practice.

For guidance on the environmental benefits of asset management to be the most useful for BC local governments, they should include specific information on how asset management can assist the local government in meeting their GHG reduction targets, as well as information on tracking and reporting the resulting environmental benefits.

2.2.3. Steering Committees

The expert interviews also found that the existence of “silos” within local government organizations was a barrier to the community achieving, or explicitly recognizing, the environmental benefits associated with the practice of infrastructure asset management. To mitigate this, the Province could promote the creation of asset management steering committees within local governments that include representation of the community’s planners as well as environmental sustainability personnel.

It is important to note that in smaller communities this option would likely not be effective, as the small size of the staff results in greater communication between departments, or the management of multiple areas by a few individuals. As such, the interviews indicated that the lack of communication between departments was not a barrier for smaller communities.

2.2.4. State of Infrastructure Asset Management

The expert interviews showed that many of the communities that participated had yet to develop an operational, formalized, and comprehensive asset management program, and rather were practicing “informal” asset management only for particular classes of assets. This was, by far, the most significant barrier to the realization of the environmental benefits outlined in the literature review. As was noted above, the paramount goal for many communities was to first be compliant with the PSAB 3150 requirements regarding the valuation of their tangible capital assets, and second to look into developing a basic asset management program. Participants noted that only after a comprehensive asset management program was implemented could a community begin to examine the possibility of applying asset management to environmental stewardship. As such, supporting communities in implementing a comprehensive, operational, and formalized asset management program would likely be the most significant contribution to promoting the use of asset management as a tool for achieving environmental sustainability in local governments across BC.

3. Empirical Data Part B: State of Asset Management in BC

The section will explore the state of asset management in BC, including the extent to which formalized asset management is currently being practiced, initiatives currently being undertaken to support asset management, the key barriers hindering the implementation and operation of an asset management program in communities, as well as the suggested recommendations provided by participants to overcome the key barriers. This section will present the relevant findings from the expert interviews and survey, as well as provide a discussion of those findings.

3.1. Findings

This section presents findings from the Ministry of Community and Rural Development's survey as well as the expert interviews. All of the interview and survey responses were compiled and then analyzed to identify the main themes common to local governments across BC. The findings are organized around the key themes that were used to structure the interview questions.

3.1.1. State of Asset Management

Survey Findings

The Ministry's asset management survey found that 16% of respondents had a formalized asset management program that was in place and operational. It is important to note, however, that the survey did not require participants to indicate if their asset management program was comprehensive. As such, the 16% of respondents that answered "yes" on this questions likely includes communities where asset management is only practiced for certain classes of assets, such as pavement.

The Ministry's survey also found that 77% of respondents intended to implement an asset management strategy in the future. It is important to note that this figure may be higher than a random sampling of local governments, as communities that completed the survey may have had a greater capacity for asset management than may be the case in the province as a whole, as was discussed above. Nevertheless these findings indicate that a relatively small percentage of respondents had implemented a formalized asset management program, and that there was strong interest in and commitment to implementing one in the future.

Table 11. State of Asset Management in BC

Survey Question	Survey Respondents (n=31)
Community has a formalized asset management program that is in place and fully operational	16 %
Community intends to implement an asset management program	77 %

In regards to the future implementation of an asset management program, the survey also asked participants to respond to a qualitative question regarding initiatives currently underway in their communities that support the development of an asset management program. Most participants noted that they were currently in the process of completing a study on the condition or capital worth of their existing assets, had incorporated their plans for developing an asset management program into their strategic plan, or were looking into acquiring asset management software. It is important to note that the findings were limited due to the short responses given by the majority of respondents.

Interview Findings

The expert interviews also explored the state of local government infrastructure asset management in BC. Specifically, participants were asked if their community currently has an asset management program that is formalized, in place, and operational. Participants were also asked if their respective local governments were planning to implement an asset management program if one was not already in place, and if the participant’s local government is currently meeting the PSAB 3150 requirements regarding the valuation of their tangible capital assets, which are widely cited as a foundation for the establishment of an asset management program.

PSAB 3150 Requirements

Most participants noted that their community is currently meeting the PSAB 3150 requirements. In addition, several also noted that because PSAB 3150 was not voluntary it gave infrastructure management a higher priority level within their organizations, particularly at the political level. This allowed asset management to be more effectively promoted in several communities to decision-makers, and helped ensure that the necessary funding was allocated to asset management development initiatives. Several participants noted that before PSAB 3150 there was no formal inventory of assets in their communities. In addition, several participants stated that as a result of PASB 3150 their community has decided to implement a comprehensive asset management program over the next several years. Other participants noted their communities have begun to implement an asset management software system as a result of PSAB 3150.

Several smaller communities (population less than 15,000) indicated that they were struggling with the implementation of PSAB 3150, and several noted that they are not yet

compliant with the requirements. Others stated that their capital asset inventory, which resulted from PSAB 3150, is at such a “high-level” that it is not useful for the management of infrastructure. It is important to note, however, that of the participants interviewed several stated that they either are meeting PSAB 3150 requirements or that meeting PSAB 3150 is their first priority in terms of infrastructure management.

Formalized Infrastructure Asset Management

The overwhelming majority of participants noted that their local government did not have a formalized and operational asset management program, but rather practiced “informal asset management.” In several communities participants noted that their local governments were starting to establish reserve funds for future infrastructure investment. Other participants stated that their communities had collected information on the condition of their assets, though communities were often not yet systematically prioritizing investments based on that information. Several participants, particularly from smaller communities (population less than 15,000) described their asset management program as being “fairly unsophisticated.” One participant, for example, noted that for sewer and water infrastructure his community’s practice of asset management consists of replacing old pipes. Several participants also described asset management in their communities as being done “off the side of the desk.”

Every participant from a community of 15,000 residents or less stated that their community only practices informal asset management. However, due to the small size of these communities, several participants noted that their infrastructure managers are aware of the equipment the community owns and its condition. One participant noted, “The public works manager lays out long rang plans, and focuses infrastructure investment on assets that are the highest priorities.” This participant also noted “this works well because high quality people have been in their positions for a long period of time, and because the size of the community allows those people to know the state of all of the large infrastructure assets in the community.”

Several participants, mostly those from communities with over 50,000 residents, noted that there was a formalized asset management program in place. However, in most instances a community’s asset management program only included particular classes of assets, such as pavement, which has a shorter life expectancy than most other infrastructure assets. Furthermore, in most instances participants noted that their community’s asset management program was not currently integrated with other departments but stated that this would likely be a consideration in the future. One participant noted that his community was planning to establish an asset management steering committee (finance, engineering, planning) to further this end, and that the community is currently moving towards synchronizing above ground and buried assets. It is also important to note that participants from communities with a formalized and operational asset management program still described that program as “fundamentally under development.”

Infrastructure Asset Management Vision

In communities without a formalized asset management program most, though not all, articulated their community's vision for asset management in the future. One participant, for example, noted that his community does not currently need a comprehensive asset management plan, as the age of his community's infrastructure is "relatively young." Another stated that due to human resource capacity constraints, their community would not be developing a formalized asset management program.

In most instances, however, participants without a formalized asset management plan stated that their goal included the implementation of an asset management program advanced enough to enable them to plan 10-30 years ahead in terms of infrastructure maintenance and replacement, as well as to establish the necessary reserve funds required to make those investments. That being said, participants also stated that their immediate goal was to be compliant with PSAB 3150, and only once that was complete would they be to develop a formalized asset management program.

3.1.2. Barriers to Asset Management

Survey Findings

The Ministry's asset management survey asked participants to identify organizational, technical, or other challenges impeding their local government from implementing or improving asset management within their community. Overwhelmingly respondents cited a lack of finances and staff capacity as the key challenges facing their organization. It is important to note that the survey findings in regards to this qualitative question were limited by the short responses given by most of the respondents.

Interview Findings

Interview participants were asked about the barriers they face in regards to maintaining or implementing an asset management program. Overall it was found that there are a wide variety of barriers that communities are facing, some of which are particular to the community's environment (i.e. a mill shutting down and reducing the local government's revenues), while others appeared to be more systemic. This section will focus on the systemic barriers that emerged from the interviews.

Funding

The most commonly cited barrier, which was noted by almost all of the interview participants, was related to long-term funding. Participants from all size communities noted that significant time and financial investments are needed to gather data, and to organize data into a format that is useful, which often included the procurement of software. One participant stated that to even make the initial purchase of the software,

without the associated staff training costs, would require more than a 1% tax increase in her community. In addition, participants noted that dedicated sources of funding are required for funding reserves to ensure that infrastructure receives investments when needed.

It is important to note that these financial barriers differ depending on the characteristics of a community. Several small communities (population less than 5,000) noted that due to the small number of infrastructure assets that they own, they could effectively manage their infrastructure without large expensive software systems. However, smaller communities have other challenges in regards to funding. Specifically it was noted that many find it difficult to raise taxes to an appropriate level, while ensuring that the cost of living is still affordable for residents. This difficulty was compounded by a variety of factors in several communities, including a declining population and thus declining tax base, the lack of industrial taxpayers, the increased cost of materials in remote communities, and the lack of a secure and dedicated funding source for asset maintenance and renewal.

Human Resource Capacity

The second most commonly cited barrier to implementing or maintaining an asset management program was noted to be human resource capacity. This barrier is directly related to the funding barrier cited above, and often the two were mentioned by participants together, as financial investment is often required to increase the “manpower needed for asset management.”

Participants from communities of every size and from every region noted that they need more people to establish and maintain an asset management program because, as one participant stated, “it takes a lot of time to manage and track data.” Another noted that if her community had the money they would “hire people to do asset management, which would require at least two full time people to do properly.”

Knowledge

Many participants also cited a lack of in-depth and technical knowledge needed to implement and run an asset management program as an additional barrier. This barrier is connected to human resources capacity and finances, as communities may not have individuals on staff with the skills necessary to implement an asset management program, or have the funding available to hire such individuals.

This barrier was noted to be exasperated in small or more remote communities, where it may be more difficult to hire individuals that have the knowledge required for asset management. One participant from a remote community noted that they “only have one individual with the skills to set up an asset management program.” Others stated that they do not have any staff onboard with the expertise required. This has lead some communities

to hire consultants, which was noted by participants to be expensive, yet necessary because there was no one within the community that would have been able to accomplish the task.

Smaller communities (population less than 15,000) noted that not having long-term staff in place is a barrier for local governments. As having long-term people in infrastructure management positions allows for informal asset management to happen, as these individuals are aware of all the assets within a community, their expected life, those assets that require priority investments, and so forth. In addition, several participants noted that the lack of succession planning in terms of infrastructure managers often means that there is little training or knowledge transfer when infrastructure managers leave or retire.

Several communities also noted that training opportunities are limited to urban centers, which is a particularly significant disadvantage for small and remote communities that also face difficulties hiring staff with the skills necessary to implement and operate an asset management program.

Priorities

Many participants also noted that a key barrier to implementing or maintaining an asset management program was the priority that asset management receives within many local governments. This was attributed to a number of factors, including that asset management is not well understood at the political level, and as such is deferred in favor of providing other services. Participants noted that this neglect at the political level results in an underinvestment in asset management. One participant noted, "It was a massive fight to get the funding to hire a person just to meet the PSAB 3150 requirements." Similarly, participants noted that funding for asset management competes for funding with popular services, which can result in infrastructure investments being deferred, or resistance to the establishment of infrastructure reserve funds.

Several participants also cited the lack of awareness the general public has regarding their community's infrastructure deficit, as well as asset management generally as an additional barrier. This lack of understanding not only allows political decision-makers to more easily neglect asset management, but it also makes the public more resistant to service or pricing changes that are necessary for the community's financial sustainability.

In addition, a number of participants cited short council terms as a key barrier. It was noted that 3 year terms makes it more difficult for political decision-makers to commit to or invest in activities that won't be realized for 20 years when the councilors are no longer in government. One participant noted, "with new local government councilors you spend the first year educating, the second year in a strategic process, and the third year trying to meet election promises, which is also during the next election."

Inter-departmental Cooperation

For communities with a population exceeding 5,000, 'silos' were noted as a key barrier. Participants from larger communities noted that their local governments were not set-up in a way that encourages collaborative or interdepartmental action. Specifically, it was noted that Finance, Engineering, Parks, and other departments operate as units unto themselves. Some participants did note however that the PSAB 3150 requirements had helped, as they required that departments collaborate to monetize their tangible capital assets.

3.1.3. Suggested Recommendations

Survey Findings

The Ministry's asset management survey also asked respondents to provide written comments identifying recommendations for improving their own asset management system. Most respondents indicated they had no recommendations or suggestions. Several respondents suggested consulting other local governments with a successful asset management program, and having the Province provide convenient training opportunities. It is important to note that the answers provided were limited due to the short responses provided by the vast majority of participants.

Interview Findings

Interview participants provided several recommendations to overcome the aforementioned barriers. The researcher also asked the communities that had been the most successful in terms of implementing an asset management program, what factors had been the most important in leading to their success.

Education

Participants emphasized that education for political decision-makers, staff, as well as the public was the most important action needed to mitigate several of the aforementioned barriers. Participants noted the need for better training at the political level regarding the infrastructure deficit and the importance of asset management in regards to infrastructure longevity and financial sustainability. Several participants stated that educating political decision makers would result in a greater willingness on their behalf to allocate financial and human resources to asset management. Specifically, participants suggested training sessions for political decision-makers at forums such as UBCM.

Interview participants also stated that better training is needed for staff in regards to implementing and operating an asset management system, which would help overcome the knowledge deficit in regards to asset management in many communities. In addition,

several participants noted that staff in all relevant departments within a local government need to be educated on “the merits of the initiative,” and specifically “why it benefits them, their department, and their city.” Participants felt that this was important in mitigating the barriers to inter-departmental collaboration, and would emphasize the importance of making time for asset management despite capacity restraints.

In regards to educating the public, participants noted that traditional methods of public consultation are not effective, and suggested that there be a creative approach to this undertaking. A few participants noted that their community had experienced success in this regard by focusing on homeowners and business associations across their community.

Guidance Documents

Several participants also suggested the creation of a provincial government sanctioned, “pool of consultants” from which local governments could draw advice at limited or no cost. Participants noted that this would allow there to be a resource they could call for assistance, when developing or operating an asset management plan, or in meeting the PSAB 3150 requirements.

It was suggested by several participants that the Province fund a team to go to each municipality to help meet the PSAB 3150 requirements, or to establish an asset management program. Others said that the Province should fund personnel for small communities to help with these tasks. Participants noted that both of these initiatives would help with standardization, and would help build capacity. In addition, participants noted that both of these options might mitigate the negative incentive associated with hiring consultants, namely that the local government’s staff is unable to strengthen their skill-set.

Financial Support

Participants disagreed on the role that grants could play to mitigate barriers. Several participants stated that more temporary funding was not the solution, as hiring more staff was the underlying problem, which requires long-term funding. To secure long-term funding several communities stated that there should be changes to the way tax revenues are allocated.

Other participants noted that grants were essential for local governments. This was particularly the case for small and remote communities. Several participants noted that grants were important in enabling them to hire consultants to do the work that no one in their communities was able to do. It was also noted by several participants that grants provided the necessary funding which enabled them to begin to gather the data necessary for asset management. Others suggested that grants be made available to help them “catch-up” in establishing reserve funds for existing assets. These participants noted that given their lack of action on asset management, and their small tax base, they were unable to

establish adequate reserve funds before the end of the useful life of some of their existing infrastructure assets.

It is also important to note that several participants suggested that their local governments needed to establish a secure and dedicated funding source for asset management, and specifically for infrastructure investment and renewal. The most successful communities in this regard noted that their reserves were funded through a sewer or water utility.

Asset Management Requirements

Three participants also stated that regulation or legislative changes were needed to overcome barriers related to “asset management neglect.” Specifically the participants noted that legislation should require that communities have an asset management plan for new infrastructure that they procure.

3.2. Discussion

This section will analyze the findings presented above, and compare those findings with the information presented in the literature review and in other documents, for the purpose of informing the recommendations made in the final section of this report.

It is important to note that this discussion will rely heavily on a report that has yet to be published from the Local Government Asset Management Working Group (LGAMWG) of BC. The Ministry, along with the Working Group commissioned a study to assess the state of asset management in BC. The study interviewed 39 local and regional governments, and assessed the responses from local governments against a ‘target’ state of asset management.

3.2.1. State of Asset Management

Overall the expert interviews and survey findings complement one another. The survey and interviews both found that a small minority of respondents practice formalized asset management, though the overwhelming majority intends to implement a formalized asset management program in the future. These findings were supported by the LGAMWG study, which also found that though the vast majority of communities had not yet developed an asset management plan, there is a strong desire and commitment to do so.

3.2.2. Provincial Guidance

The interview results, as well as the findings in the LGAMWG study, demonstrate that there are a wide variety of challenges facing local governments in regards to developing and establishing an asset management program. The interviews and the LGAMWG study also

indicate that the largest contribution the provincial government could make to supporting the development of an asset management program would be in terms of providing guidance and support. To maximize the effectiveness of this guidance the Province should focus on securing long-term funding for asset management, gathering data, putting data into a useable format, promoting the public's awareness of asset management, inter-departmental co-operation, and guidance for newly elected local government officials. The expert interviews, survey, as well as the LGAMWG study all emphasized these areas as current and significant barriers to the implementation and operation of asset management.

In addition to providing written guidance, the Province should consider establishing a resource for communities to receive specific guidance in regards to the development, implementation, or maintenance of their asset management program. This could include 'consultants' employed by the provincial government and provided to local governments. In addition to providing general support to local governments this may also result in the strengthening of local government internal capacity. Specifically, it may allow local government staff to further develop their skill sets, as opposed to becoming partially dependent on private consultants that have an interest in maintaining a local government's reliance on private consultation.

3.2.3. Provincial Grants

A lack of funding was the primary barrier noted by interview participants, as well as by respondents to the Ministry's survey. This finding was also present in the LGAMWG study.

The research findings indicate that though provincial grants have a role to play, local governments must find stable long-term funding sources to support asset management for them to be successful. The LGAMWG study found that assets management funded through dedicated utilities was much more successful than funding through general taxation. This finding was supported by the expert interviews, as participants noted that funds from general taxation competed against other higher priority services.

The findings also indicate that grants may be most successful in supporting asset management if they are targeted at building human resource capacity and knowledge in small, remote communities. This could include training grants for staff, or grants focused on providing communities with additional full time employees over an extended period of time. Grants that also promote the use of reserve funds for existing assets would also help local governments mitigate the barrier to setting up a reserve fund in the middle of the life of an existing asset, as well as the disincentive to redirect resources from other services.

3.2.4. Additional Funding

The interviews, along with the LGAMWG study found that a significant barrier to local governments establishing an asset management program was the lack of long-term secure funding. Successful communities in this regard often secured funds for asset maintenance

and renewal through dedicated utilities, such as sewer and water. Establishing dedicated funding sources also removes the disincentive to redirect financial resources from other and often more popular services. It is important to note that establishing dedicated funding sources for all infrastructure assets may not be possible. While water and sewer utilities offer a clear potential for collecting dedicated revenue, other infrastructure assets such as roads and civic buildings do not produce revenue for local governments, and as such establishing a dedicated revenue stream is significantly more difficult.

3.2.5. Legislation

The expert interviews found that though several communities were struggling with the implementation of the PSAB 3150 requirements regarding the valuation of tangible capital assets, many had realized significant benefits in terms of advancing their community's asset management program. This finding was supported by the LGAMWG study, which also found that the PSAB 3150 requirements resulted in local governments making advancements in terms of asset management, by requiring interdepartmental cooperation, as well as the establishment of an inventory of capital assets that include their monetized worth. The success of PSAB 3150 in motivating local governments to advance asset management may be replicated by the use of other regulatory or legislative changes to promote asset management in BC.

Specifically, several of the interview participants noted that prioritizing asset management was a key barrier for many communities. Survey respondents also noted this, as did participants in the LGAMWG study. To help mitigate this barrier the Province could consider implementing legislative or regulatory changes, which promote asset management generally. This could include, as was suggested by several participants, a requirement that an asset management plan be developed for new infrastructure.

3.2.6. Public Engagement

The expert interviews found that a lack of awareness of the current infrastructure deficit, the cost of renewal currently facing communities, and the general practice of asset management was a key barrier in making asset management a priority within local governments. To mitigate this, several participants suggested greater transparency in terms of the state of infrastructure within a community. Participants in the LGAMWG study made similar suggestions, including the requirement that local governments publish information regarding the state of their infrastructure.

It is also important to note that the expert interviews found that targeting civic engagement regarding asset management to homeowner and business associations was particularly successful.

4. Recommendations

This section recommends various actions the provincial government could take to promote the use of asset management as a tool to promote environmental sustainability in local governments across BC. It is important to note that the most significant action the provincial government could take in this regard is supporting communities in implementing a comprehensive, operational, and formalized asset management program, as it was found that the absence of an asset management program was the most significant barrier to achieving the environmental benefits outlined in the literature review.

4.1. Provincial Guidance

To assist local governments in identifying and achieving the environmental benefits that result from the application of infrastructure asset management, the Province should develop guidance materials, which outline the environmental benefits associated with the practice of asset management. To maximize their effectiveness these guidance materials should include specific information on how these initiatives can assist the local government in meeting their GHG reduction targets, as well as information on tracking and reporting the resulting environmental benefits.

To assist local government in the development and operation of an asset management program generally, the provincial government should also consider developing a variety of guidance materials for local government staff, in addition to guidance for newly elected local government officials on the importance of asset management. The guidance materials for staff should focus on how to:

- Secure long-term funding for asset management;
- Gather relevant data, as well as how to put data into a useable format;
- Promote inter-departmental co-operation; and
- Effectively engage the public in order to promote awareness of asset management, with a particular emphasis on homeowner and business associations

The provincial government should also explore ways in which it could provide resources to communities that address their individual needs, without requiring significant financial expenses on behalf of the local government. This could include a provincially funded consultant, or team of consultants that local governments could use as an information resource when needed. This would be particularly useful for small and remote communities.

4.2. Steering Committees

The Province should promote the creation of asset management steering committees within local governments, for the purpose of promoting the inter-departmental collaboration necessary for asset management, as well as to assist communities in

identifying and achieving the environmental benefits that result from the application of asset management. Steering committees should include individuals in senior Finance, Engineering, Operations, Administration, Planning, and Environment-related positions.

4.3. Legislative or Regulatory Change

To ensure that asset management is a priority for local governments across BC, the provincial government should consider requiring that local governments have an asset management plan for all new infrastructure assets that they procure. For this option to be successful, the provincial government would need to undertake more research to ensure that an onerous burden would not be placed on small communities.

4.4. Public Engagement

The Province should encourage local governments to educate their residents on their community's infrastructure deficit, as well as their community's plan for financial sustainability in regards to infrastructure. This could include a requirement that local governments publish this information annually.

4.5. Provincial Grants

The Province should consider creating grants targeted to small and remote communities for the purpose of strengthening their human resource and knowledge capacity. Grants could include funding for small, remote communities to hire additional staff members to assist with the implementation and operation of asset management, as well as to fund training opportunities regarding asset management. Grants could also be used to support communities in procuring asset management software, including the costs associated with staff training.

The Province should also consider encouraging the development of reserve funds for existing assets. This could include a fund matching program, where eligible communities receive a percentage of the amount that they contribute to a reserve fund for existing assets.

4.6. Additional Funding

The provincial government should encourage communities to establish long-term and secure funding for asset management, where possible. This could include encouraging communities to fund asset management for infrastructure through dedicated utilities, as opposed to general taxation.

CONCLUSION

This report has demonstrated that local government infrastructure asset management can result in significant environmental benefits when applied to the management of existing infrastructure, the procurement of new infrastructure, and the preservation and maintenance of natural infrastructure. Identifying these benefits was significant in that they add an environmental rationale for the practice of asset management, in addition to the financial and social rationales that have been discussed widely in the literature. Given the demonstrated environmental commitment of many of BC's local governments, this addition to the literature will likely be important in promoting the use of asset management in the future. Furthermore, developing an understanding of how asset management can result in environment benefits was also an important first step in identifying the ways in which the Province can support local governments in using this practice as a tool for environmental sustainability.

This report also explored the extent to which infrastructure asset management was used by BC local governments as a tool for achieving their environmental goals, for the purpose of supplementing the findings of the literature review, given the lack of literature on the topic. This also helped to identify the ways in which the Province might support local governments in using asset management to achieve various environmental objectives. In the end, it was determined that supporting communities in implementing a comprehensive, operational, and formalized asset management program would likely be the most significant contribution to promoting the use of asset management as a tool for achieving environmental sustainability in local governments across BC.

Along this line, this report also identified the current state of local government infrastructure asset management in BC. This allowed the researcher to identify the key challenges hindering the implementation or operation of an asset management program, and identify general recommendations to mitigate these challenges

Some possible future lines of research have also emerged from this project. Specifically, additional research is needed to explore the extent to which environmental benefits, such as GHG emission reductions, are realized from specific asset management related activities. In many instances there is only the general recognition of 'significant benefits', without information regarding the quantity of those benefits. The availability of more precise information would likely add an additional impetus for the use of asset management as a tool for environmental sustainability. Additional research is also needed that identifies best practices in supporting local government infrastructure asset management. Along this line, additional research is needed into some of the recommendations posited in this report for the purpose of determining how similar actions have worked in other jurisdictions, the full impact of these recommendations on BC local governments, and the ways in which these recommendations should be implemented.

In conclusion, since infrastructure is a central component of the activities of local governments, and since the environment is an increasing priority for local governments, the need to bring these two priorities together is especially apparent. Infrastructure asset management brings these two areas together, allowing local governments to realize significant financial and environmental benefits. This is particularly important in light of the current infrastructure deficit, the global financial downturn, and the serious threats posed by climate change and environmental degradation.

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APPENDICIES

Appendix A – Interview Participant Consent Form

School of Public Administration,
University of Victoria

Participant Consent Form

An Environmental Perspective on Local Government Infrastructure Management

You are invited to participate in a study entitled “An Environmental Perspective on Local Government Infrastructure Asset Management” that is being conducted by Jasun Fox.

Jasun Fox is a graduate student in the department of Public Administration at the University of Victoria and you may contact him if you have further questions by email at jasun.fox@gov.bc.ca or by telephone at 250.952.6582.

As a Graduate student, Jasun Fox is required to conduct a research project as part of the requirements for a degree in Public Administration. This research is being conducted under the supervision of Dr. Emanuel Brunet-Jailly. You may contact the academic supervisor at 250.721.6418.

Purpose and Objectives

The purpose of this research project is to identify the environmental benefits of implementing infrastructure asset management principles at the local government level, for the purpose of further promoting asset management as a best practice for communities in BC. This project also aims to identify ways in which local governments can be better supported by the Province in implementing an asset management strategy.

Importance of this Research

Research of this type is important because it provides another way in which local government infrastructure asset management can be promoted as a best practice. Currently, many infrastructure projects are reactive, and focused on immediate or short-term benefits. Asset management is needed to ensure that long-term costs are incorporated into decision-making, to help ensure the long-term fiscal sustainability of British Columbia’s local governments.

This project is also important because it will identify the extent to which BC’s local governments practice asset management, and provide recommendations on how local governments can be more adequately supported in this regard by the provincial government. This will be accomplished through exploring common barriers and challenges that local governments are facing in planning for the long-term costs associated with infrastructure assets.

Participants Selection

You are being asked to participate in this study because of your employment position at a local government in BC.

What is Involved

If you agree to voluntarily participate in this research, your contribution will include participating in a telephone interview regarding the extent to which asset management is practiced by your local government, and the ways in which this practice has supported environmental stewardship. During the telephone interview the researcher will take written notes. Participating in the interview should take less than 30 minutes.

Inconvenience

Participation in this study may cause some inconvenience to you, namely the use of your time to participate in the interview.

Risks

There are no known or anticipated risks to you by participating in this research.

Benefits

This research project will contribute to the state of knowledge on the environmental benefits of local government infrastructure asset management, which has been understudied. This research will benefit the participants and their communities, as they will be able to further promote asset management as a best practice in their local governments by citing the environmental benefits.

This project will also explore the state of infrastructure asset management in BC, including the common barriers hindering the implementation of an asset management strategy at the local government level. The identification of these barriers, and the corresponding recommendations, will benefit the participants, as well as communities across BC, as it will identify the ways in which the Provincial government can better support local governments to implement asset management principles.

Voluntary Participation

Your participation in this research must be completely voluntary. If you do decide to participate, you may withdraw at any time without any consequences or any explanation. If you do withdraw from the study the information you provided will only be used with your written permission.

Anonymity

In terms of protecting anonymity, all of the data obtained from the interviews will be aggregate so that individual communities will not be able to be identified in the final report, unless there is written permission from you to use a particular action that your community has taken as a best practice example. In this instance you will have an opportunity to review the section of the report that identifies your community before the report is

Appendix B – Interview Recruitment Material

Dear _____,

I am a Master of Public Administration student at the University of Victoria, and I am currently completing my third co-op work term at the Ministry of Community and Rural Development. In addition, I am currently working on a client-based thesis project for the Ministry, which will focus on the environmental benefits of infrastructure asset management at the local government level.

I am contacting you because I am hoping to conduct an interview with you to discuss the extent to which asset management is practiced at your local government, and any ways in which the practice of asset management has resulted in environmental benefits. The purpose of exploring the environmental benefits to infrastructure asset management is to provide local government staff, as well as the Ministry, with another way in which asset management can be promoted as a best practice. I will also use this information to identify ways in which local governments can be better supported by the Province in implementing an asset management program.

It is important to note that although I may use information that you provide, my report will not disclose your name or identify your community. I will be conducting interviews until the end of April. If you are able to participate, please let me know at your earliest convenience.

Additionally, if you have any questions about this project, please do not hesitate to contact me (250.952.6582). Furthermore, please feel free to contact Stephanie Walton (my client for this project at the Ministry of Community and Rural Development) at 250.356.0283 or Stephanie.Walton@gov.bc.ca. You can also contact my academic supervisor, Dr. Emmanuel Brunt-Jailly at 250.721.6418 or ebrunetj@uvic.ca.

Thank you for your time and for any help you can provide.

Sincerely,

Jasun Fox

Policy Analyst (Co-op), Intergovernmental Relations & Planning Division
Ministry of Community and Rural Development
6th Floor 800 Johnson Street, Victoria BC V8W 92T
250.952.6582 (Office)
250.661.8278 (Home)

Appendix C – Interview Themes and Explanatory Notes

Interview Themes	Explanatory Note
The state of infrastructure asset management in the community	<p>An infrastructure asset management program allows a community to plan for the long-term costs associated with the operation, maintenance, rehabilitation, disposal, and renewal of their infrastructure. This includes articulating service levels, as well as identifying the condition of infrastructure assets, so that necessary future investments can be identified and prioritized.</p> <p>The passage of PSAB 3150 has resulted in local governments across Canada valuing their existing infrastructure assets, which can provide the foundation for an asset management program.</p>
Barriers the local government is facing with respect to implementing/maintaining an asset management program	The literature noted human capacity, funding, organizational, and technical barriers.
Environmental benefits realized from managing existing infrastructure	The literature noted that some environmental benefits might result when asset management principles are applied to a local government's existing infrastructure. For example, assessing the condition of assets results in the identification and repair of water leaks. This can result in significant water and energy savings for a community. Ensuring that the necessary maintenance of infrastructure occurs may also extend the useful life of that asset, which reduces the environmental impacts associated with the disposal of the asset and the construction of new infrastructure.
Environmental benefits realized from purchasing new infrastructure when asset management principles are applied	If long-term costs are considered when infrastructure is purchased, this may lead to environmental benefits. For example, infrastructure that uses less energy or that allows for waste products, such as sewage, to be used as a resource may reduce overall lifecycle costs, even though the purchase is more expensive initially.

	<p>Land-use decisions may also be impacted. For example, sprawl increases long-term infrastructure costs associated with maintenance and replacement, as infrastructure systems need to be expanded significantly in newly developed areas.</p> <p>Development that is concentrated in a single area makes use of existing infrastructure, a practice that reduces costs and environmental impacts. It has clear environmental benefits, as the environmental impacts associated with maintaining and replacing a larger infrastructure system is avoided. There are also significant community-wide GHG-related benefits realized from reduced transportation emissions.</p>
<p>Environmental benefits from the management of 'natural infrastructure'</p>	<p>Natural Infrastructure (also called Green Infrastructure) can include parks, watersheds, greenways, forests, and the like. Natural Infrastructure can provide a variety of functions and services if protected and managed well. These include flood mitigation, storm water management, and drought mitigation, among others.</p>

Appendix D – Asset Management Survey



MINISTRY OF COMMUNITY AND RURAL DEVELOPMENT
Infrastructure Branch
Asset Management Reporting

PLEASE COMPLETE AND E-MAIL A DIGITAL COPY OF THIS FORM TO: infra@gov.bc.ca
USE THE FOLLOWING SUBJECT LINE IN THE E-MAIL: ASSET MANAGEMENT REPORT

READ ASSET MANAGEMENT REPORTING GUIDE FROM MORE INFORMATION

COMMUNITY / RECIPIENT INFORMATION			
Community / recipient name			
Project title			
Project number			Date
Form completed by (name and position) ONLY COMPLETE GREEN CELLS			(mm/dd/year)

PLEASE NOTE: "NO" answers do not jeopardize payment approval of grant claims.

1. Asset Management System Overview		
Use the "Yes" or "No" drop buttons in the right hand columns.		claim
1.a	Does your community have a formalized Asset Management strategy that is in place and fully operational?	
1.b	If you answered no to the question above, does your community intend to implement an Asset Management strategy?	
1.c	Does your community use software specifically designed for Asset Management?	
1.d	If you answered yes to the above question please identify the name and/or type of software system used.	
1.e	Does your Asset Management system have a geographical information system (GIS) component?	
1.f	If you answered yes to the above questions is the GIS a component of a specifically designed Asset Management software system?	
1.h	If you answered yes to the above question, does your software have a capital maintenance management system component?	
1.i	Does your Asset Management strategy account for life cycle analysis?	
1.j	Does your Asset Management strategy employ infrastructure performance analysis (benchmarking)?	
1.k	In the space below describe any other software that you use for your Asset Management system. COMMENTS:	

2. State of Knowledge Regarding Capital Assets

Rate your organization's current state of knowledge on the following criteria for all existing capital assets ONLY for the applicable system (e.g. water projects, comment on the community's current understanding of assets relating to the entire drinking water system).

Use the following rating scheme from the drop buttons in the right column:		3 = little to no knowledge gaps 2 = few knowledge gaps 1 = several knowledge gaps 0 = many knowledge gaps
How would you rate your knowledge on the following attributes:		claim
2.a	capital asset inventory	
2.b	location of all inventory	
2.c	condition assessment of all inventory	
2.d	age of all inventory	
2.e	book value of all inventory	
2.g	residual life of all inventory	
2.h	Overall State of Knowledge Regarding Capital Assets	

3.a	Is your Asset Management system integrated with your financial management system?	
3.b	Will your Asset Management system support the 2009 Public Sector Accounting Board 3150 (PSAB) requirements?	
3.c	If you answered yes to the above question (3.a), In the space below describe how your Asset Management system will be used to meet the PSAB requirements. COMMENTS:	

4. Additional Questions

4.a	Highlight any current policies, procedures or plans that support asset management. COMMENTS:
4.b	Describe any future or current initiatives that are underway which will improve asset management. COMMENTS:
4.c	Describe how your organization ensures that sufficient funding is in place for replacement of an COMMENTS:
4.d	Identify recommendations for improving your Asset Management system. COMMENTS:
4.e	Identify organizational, technical or other challenges impeding your organization from implementing COMMENTS:
4.f	Provide suggestions for best management practices for Asset Management. COMMENTS:
4.f	How will you manage the new assets being constructed as a result of this funding? COMMENTS:

Appendix E – Initiatives Identified by Interview Participants

Infrastructure Management Area	Initiative	Environmental Benefit
Existing infrastructure	Installation of water meters on residential homes.	Water and energy conservation from reduced consumption. Avoided environmental impacts associated with system expansion.
Existing infrastructure	Volume-based pricing for water consumption.	Water and energy conservation from reduced consumption. Avoided environmental impacts associated with system expansion.
Existing infrastructure	Consideration of environmental risk when prioritizing infrastructure investments.	Avoided environmental degradation.
Procurement of new infrastructure	Land-use planning focused on compact communities.	GHG emission reduction from decreased transportation. Avoided environmental impacts associated with infrastructure system expansion.
Existing infrastructure	Low-flush toilet rebate program, as well as rebate programs for efficient washers and dryers.	Water and energy conservation from reduced consumption. Avoided environmental impacts associated with system expansion.
Procurement of new infrastructure	Procuring energy efficient pumps and motors for water systems, as well as energy efficient sewer pipes.	Reduces energy consumption and associated GHG emissions.
Procurement of new infrastructure	Requiring developers to include infrastructure services in design.	Avoided environmental impacts associated with infrastructure expansion.
Procurement of new infrastructure	Building narrower roads.	Reduces environmental impacts associated with clearing land to pave the road, as well as the embodied energy associated with road construction.
Existing infrastructure	Street light dimming.	Reduces light pollution, energy consumption, and associated GHG emissions.
Existing infrastructure	Integrated management of buried and above-ground assets	Reduced GHG emissions and embodied energy associated with rework.

Procurement of new infrastructure	Setting up power generators in storm sewers.	Reduced energy consumption and associated GHG emissions.
Natural infrastructure	Protection of watershed.	Avoided environmental degradation.
Procurement of new infrastructure	Geothermal and gravity powered sewer system.	Energy and GHG emissions reduction.
Natural infrastructure	Storm water management plan.	Protected green space and detention ponds. Avoided environmental impacts associated with infrastructure construction.
Procurement of new infrastructure	Solar energy installation for city hall and other municipal buildings. Replacement of street lights to LED lighting.	Energy and GHG emissions reduction.