

# **Ecosystem-based Adaptation to Climate Change in Urban Areas: An Evaluation of Rainwater Management Practices in Metro Vancouver**

**By**

**Julia Berry**

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# Approval

**Name:** Julia Berry  
**Degree:** Master of Resource Management

**Report Number:** 637

**Title:** *Ecosystem-based Adaptation to Climate Change in Urban Areas: An Evaluation of Rainwater Management Practices in Metro Vancouver*

**Examining Committee:** **Chair:** Chloe Boyle  
Master of Resource Management Candidate

**Sean Markey Ph.D.**  
Senior Supervisor  
Associate Professor

---

**Kim Stephens**  
Supervisor  
Executive Director, Partnership  
for Water Sustainability BC

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Date Defended/Approved:

January 7, 2016

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## Ethics Statement



The author, whose name appears on the title page of this work, has obtained, for the research described in this work, either:

- a. human research ethics approval from the Simon Fraser University Office of Research Ethics,

or

- b. advance approval of the animal care protocol from the University Animal Care Committee of Simon Fraser University;

or has conducted the research

- c. as a co-investigator, collaborator or research assistant in a research project approved in advance,

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## **Abstract**

Adapting to climate change will require a combination of approaches, from man-made infrastructure to holistic approaches. British Columbia's Integrated Stormwater Management Plans (ISMPs) promote a holistic approach to rainwater management, which views rain as a resource and aims to mimic the natural hydrological cycle by allowing rainwater to return directly to the ecosystem. Ecosystem-based adaptation (EbA) is a novel approach to planning and adaptation that prioritizes ecosystem services, enhancing biodiversity, as well as human health and wellbeing. This research uses a framework of EbA principles to evaluate select ISMPs from the City of Surrey and City of Coquitlam. While the intended purpose of ISMPs is not directly to address climate change, the results of the research show that municipalities in Metro Vancouver are already successfully implementing the principles of EbA through ISMPs in the urban context.

**Keywords:** Ecosystem-based Adaptation; Integrated Stormwater Management Plans, Climate Change; Adaptation; Metro Vancouver

*For the one and only, Shannon Matthews.*

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## List of Acronyms

BC	British Columbia
BCS	Biodiversity and Conservation
DCC	Development Cost Charge
EbA	Ecosystem-based Adaptation
EBM	Ecosystem-based Management
EMS	Ecosystem Management Study
GHG	Greenhouse Gas
GIN	Green Infrastructure Network
IDF	Intensity, Duration, Frequency
IPCC	Intergovernmental Panel on Climate Change
ISMP	Integrated Stormwater Management Plan
IWMP	Integrated Watershed Management Plan
LID	Low Impact Development
MEA	Millennium Ecosystem Assessment
NRTEE	National Roundtable on the Environment and the Economy
OCP	Official Community Plan
PCIC	Pacific Climate Impacts Consortium
SILG	Stormwater Interagency Liaison Group
TIA	Total Impervious Area
UHI	Urban Heat Island
UNEP	United Nations Environmental Programme
WBM	Water Balance Model

## Executive Summary

Water is the lifeblood of an ecosystem, but when it falls on a city of impervious surfaces, it is called stormwater and regarded a liability (Stephens, Graham, & Reid, 2002). Traditional development and stormwater management practices have resulted in buried streams, polluted waterways, and flooded neighbourhoods creating a deficit of the natural spaces well documented to promote human health and wellbeing (Spirn 1984; Kaplan, 1995; Pinkham, 2000; Roy, Paul, & Wenger, 2010). In 2002, the Government of British Columbia (BC) updated traditional stormwater management regulation with a holistic approach outlined in *Stormwater Planning: A Guidebook for British Columbia*. The ISMP guidelines cite the threats from climate change to aging stormwater infrastructure as one of many rationales for integrating land use planning and stormwater management (Stephens, Graham, & Reid, 2002). The result of integrating land use planning and rainwater-stormwater management through ISMPs (also known as Watershed Blueprints or Integrated Watershed Management Plans) may provide an opportunity to integrate ecosystem-based solutions to climate change into ecologically focused rainwater management plans.

Climate change projections anticipate that by 2050 Metro Vancouver will experience an average annual increase in temperature of 1.7°C, a change in annual precipitation between -4% and +15%, with less precipitation in the summer and more in the winter, and an increase in both frequency and intensity of rain events (City of Surrey, 2013a). Adapting to a changing climate will require a combination of approaches, from man-made infrastructure to holistic approaches (UNEP, 2012). The United Nations Environmental Programme (UNEP) is researching the principles and practices of a new concept that integrates ecosystem management practices into climate change adaptation plans (UNEP, 2012). Ecosystem-based adaptation (EbA) is a novel approach to planning and adaptation that prioritizes ecosystem services, enhancing biodiversity, as well as human health and wellbeing (Colls, Ash, & Ikkala, 2009). EbA is a relatively new concept in practice and there is a lack of information about EbA technologies compared to man-made infrastructure adaptation solutions (Travers, Kay, Carmen Elrick, & Vestergaard, 2012). Similarly, a meta-analysis of adaptation actions by Ford, Berrang-Ford and Paterson (2011) found it is more common for proposed actions, rather

than implemented actions, to be reported on by academic literature, which likely reflects society's early stage in the adaptation process. My research will address the gap in knowledge identified by the Travers et al., Ford et al. by evaluating completed ISMPs, and watershed plans for the inclusion EbA principles.

The aim of the research is to demonstrate the implementation of EbA principles through stormwater management plans in Metro Vancouver and highlight how ISMPs facilitate resilient infrastructure in urban areas. A systematic assessment of ISMPs for the inclusion of EbA principles was conducted to investigate whether ISMPs are implicitly implementing EbA principles in urban areas. Prior to the evaluation, a literature review was completed to understand the core concepts of the research, such as adaptation planning, ecosystem-based management (EBM), EbA, as well as the context of stormwater planning in BC. In addition, the literature was instrumental for creating the evaluation framework, which was developed specifically for this research project. The evaluation was completed on two ISMPs from the City of Surrey and two IWMPs from the City of Coquitlam. In addition, non- ISMP documents were evaluated, such as municipal, regional, and provincial policy, adaptation planning, and stormwater management guiding documents to illuminate connections between the ISMPs and broader planning context. Key stakeholders were interviewed to assist with the evaluation process.

The results of the evaluation indicate that both the City of Coquitlam and the City of Surrey are both already implementing many principles of EbA through their ISMPs. The results of this research will be particularly interesting to regional and municipal stormwater and adaptation planners who are seeking ecosystem-based solutions for addressing climate change in urban areas. The four ISMPs evaluated in the research project are not only examples of successful ISMPs; but they also demonstrate that select ISMPs are already achieving many of the indicators of EbA. While the intended purpose of ISMPs may not be to address climate change, the results of the research show that municipalities in Metro Vancouver are already successfully implementing most EbA principles through ISMPs. This is particularly significant because it demonstrates that EbA is implementable in the urban context through the ISMP process.

These findings also contribute to broader discussions of the applicability of utilizing ecosystem-based urban design practices to help cities adapt to climate change. Urban and regional planners interested in climate change adaptation will find this research particularly interesting as this project identifies rainwater management as a great opportunity for integrating EbA into urban areas, as well as providing evidence that ISMPs are an appropriate tool for implementing EbA. Changing the urban form can be a costly and slow process. Many regions in Canada have already experienced the negative impacts of a changing climate and are looking for innovative and cost effective planning strategies to mitigate and adapt to climate change. Finding solutions to reduce future infrastructure costs while adapting to climate change is a win-win scenario. Before local governments will commit to costly upgrades to the urban form in the name of sustainability and climate change resilience, they often require examples that outline the proven success of similar upgrades elsewhere.

The results of this study indicate that EbA principles are incorporable into urban planning contexts, especially for sustainable rainwater management that is responsive to climate variations both present and future. The City of Surrey and City of Coquitlam are already regarded as leaders in integrated stormwater planning in BC (Urban Systems, 2012) and the results of this research show they are both leaders in implementing the principles of EbA in the urban context through rainwater management. In other words, cities across the country and from around the world can look to Surrey and Coquitlam as examples of municipalities that have successfully implemented principles EbA in the urban context.

# Chapter 1.

## INTRODUCTION

Water is the lifeblood of an ecosystem, but when it falls on a city of impervious surfaces, it is called stormwater and regarded a liability (Stephens, Graham, & Reid, 2002). Traditional development and stormwater management practices have resulted in buried streams, polluted waterways, and flooded neighbourhoods creating a deficit of the natural spaces well documented to promote human health and wellbeing (Spirn 1984; Kaplan, 1995; Pinkham, 2000; Roy, Paul, & Wenger, 2010). In 2002, the Government of British Columbia (BC) updated traditional stormwater management regulation with a holistic approach outlined in *Stormwater Planning: A Guidebook for British Columbia*. Integrated Stormwater Management Plans (ISMPs), as outlined in the guidebook, promote rainwater management, which views rain as a resource and aims to mimic the natural hydrological cycle by allowing rainwater to return directly to the ecosystem instead of using only man-made infrastructure to transport rainwater to an outsource (Stephens, Graham, & Reid, 2002). The ISMP guidelines cite the threats from climate change to aging stormwater infrastructure as one of many rationales for integrating land use planning and stormwater management (Stephens, Graham, & Reid, 2002). The result of integrating land use planning and rainwater-stormwater management through ISMPs (also known as Watershed Blueprints or Integrated Watershed Management Plans) may provide an opportunity to integrate ecosystem-based solutions to climate change into ecologically focused rainwater management plans.

Climate change projections anticipate that by 2050 Metro Vancouver will experience an average annual increase in temperature of 1.7°C, a change in annual precipitation between -4% and +15%, with less precipitation in the summer and more in the winter, and an increase in both frequency and intensity of rain events (City of Surrey, 2013a). Adapting to a changing climate will require a combination of approaches, from man-made infrastructure to holistic approaches (UNEP, 2012). The United Nations Environmental Programme (UNEP) is researching the principles and practices of a new concept that integrates ecosystem management practices into

climate change adaptation plans (UNEP, 2012). Ecosystem-based adaptation (EbA) is a novel approach to planning and adaptation that prioritizes ecosystem services, enhancing biodiversity, as well as human health and wellbeing (Colls, Ash, & Ikkala, 2009). EbA is a relatively new concept in practice and there is a lack of information about EbA technologies compared to man-made infrastructure adaptation solutions (Travers, Kay, Carmen Elrick, & Vestergaard, 2012). Similarly, a meta-analysis of adaptation actions by Ford, Berrang-Ford and Paterson (2011) found it is more common for proposed actions, rather than implemented actions, to be reported on by academic literature, which likely reflects society's early stage in the adaptation process. My research will address the gap in knowledge identified by the Travers et al., Ford et al. by evaluating ISMPs for the inclusion EbA principles.

The holistic approach of ISMPs outlined by Stephens, Graham, & Reid (2002) is similar to the principles of EbA outlined by Huq, Renaud, and Sebesvari (2013). This research project will assess select ISMPs in Metro Vancouver using an evaluative framework to identify the inclusion of EbA principles. **The aim of the research is to demonstrate the implementation of EbA principles through stormwater management plans in Metro Vancouver and highlight how ISMPs facilitate resilient infrastructure in urban areas.**

## **1.1. Methods:**

A systematic assessment of ISMPs for the inclusion of EbA principles was conducted to investigate whether ISMPs are implicitly implementing EbA principles in urban areas. Prior to the evaluation, a literature review was completed to understand the core concepts of the research, such as adaptation planning, ecosystem-based management (EBM), EbA, as well as the context of stormwater planning in BC. In addition, the literature was instrumental for creating the evaluation framework, which was developed specifically for this research project. The evaluation was completed on two ISMPs from the City of Surrey and two IWMPs from the City of Coquitlam. In addition, non- ISMP documents were evaluated, such as municipal, regional, and provincial policy, adaptation planning, and stormwater management guiding documents to illuminate connections between the ISMPs and the broader planning context. Key stakeholders were interviewed to assist with the evaluation process.

The results of the evaluation showed that the City of Surrey and City of Coquitlam municipalities are incorporating EbA principles through their ISMPs. Both cities scored well on

the evaluation, with Surrey receiving slightly higher overall scores resulting from meeting indicators of the Knowledge Based Adaptation principle. The only one indicator from the framework that neither municipality met was Accountable and Transparent Decision Making.

## **1.2. Significance:**

The results of the evaluation indicate that both the City of Coquitlam and the City of Surrey are both already implementing many EbA principles through their ISMPs. The results of this research will be particularly interesting to regional and municipal stormwater and adaptation planners who are seeking ecosystem-based solutions for addressing climate change in urban areas. The four ISMPs evaluated in the research project are not only examples of successful ISMPs; but they also demonstrate that select ISMPs are already achieving many of the indicators of EbA. While the direct purpose of ISMPs may not be to address climate change, the results of the research show that municipalities in Metro Vancouver are already successfully implementing most EbA principles through ISMPs. This is particularly significant because it demonstrates that EbA is implementable in the urban context through the ISMP process.

These findings also contribute to broader discussions of the applicability of utilizing ecosystem-based urban design practices to help cities adapt to climate change. Urban and regional planners interested in climate change adaptation will find this research particularly interesting as this project identifies rainwater management as a great opportunity for integrating EbA into urban areas, as well as providing evidence that ISMPs are an appropriate tool for implementing EbA. Changing the urban form can be a costly and slow process. Many regions in Canada have already experienced the negative impacts of a changing climate and are looking for innovative and cost effective planning strategies to mitigate and adapt to climate change. Finding solutions to reduce future infrastructure costs while adapting to climate change is a win-win scenario. Before local governments will commit to costly upgrades to the urban form in the name of sustainability and climate change resilience, they often require examples that outline the proven success of similar upgrades elsewhere. The City of Surrey and City of Coquitlam are already regarded as leaders in integrated stormwater planning in BC (Urban Systems, 2012) and the results of this research show they are both leaders in implementing the principles of EbA in the urban context through rainwater management. In other words, cities across the country and from around the world can look to Surrey and Coquitlam as examples of municipalities that have successfully implemented principles EbA in the urban context.

### **1.3. Paper Outline**

To present this research, a literature review will first explore the core concepts of adaptation planning and EbA, followed by the BC context for stormwater management and climate change impacts. The subsequent section will then elaborate on the methods used to complete the literature review, the development of the evaluation criteria, the evaluation processes, and last, analyze the results of the evaluation. The succeeding section will describe the case study ISMPs evaluated from the City of Coquitlam and City of Surrey. The results of the evaluation are presented in detail in the penultimate section. Lastly, the discussion section examines the significance of the research in the regional, national, and global contexts.

## Chapter 2.

### LITERATURE REVIEW

The core concept of the research project, EbA, is a combination of two other significant concepts: EBM and climate change adaptation. The following section will first explore various aspect of adaptation planning, including why cities need to be addressing the impacts of climate change, opportunities for local governments in Canada to implement adaptation, the no-regrets adaptation planning approach, and last, Canada's current infrastructure deficit. Next, the literature review establishes a strong foundational understanding of the EbA by exploring the connection between of EBM and climate change adaptation actions, examining the key concepts of EbA, and finishes with a description of EbA's economic, environmental, and social benefits.

#### 2.1. Adaptation Planning

The impacts of climate change are occurring around the world and planners, policy makers, and engineers face the challenge of preparing appropriate plans to mitigate the effects of climate change on the built environment. There are two fundamental responses to anthropocentric climate change: mitigation and adaptation. Mitigation refers to lessening global climate change by either reducing and/or eliminating greenhouse gas (GHG) emissions or enhancing GHG sinks (Fussel, 2007). Adaptation, as defined by the Intergovernmental Panel on Climate Change (IPCC), is "actions that reduce the negative impact of climate change and/ or take advantage of new opportunities. It involves making adjustments in our decisions, activities and thinking because of observed or expected changes in climate" (IPCC, 2007, pp.). The process of taking action to reduce risks and capitalize on opportunities is referred to as *adaptation planning* in this report.

Fussel (2007) identifies several reasons why adaptation is important today and will continue to be important in the future. First, Fussel (2007) notes that anthropocentric GHG

emissions are affecting the global climate. NASA and NOAA both found 2014 to be the hottest year on record, which resulted in extreme heat and flooding in many parts of the world (NASA, 2015). The average global temperature was approximately “0.57° Centigrade (1.03 Fahrenheit) above the average of 14.00°C (57.2 °F) for the 1961-1990 reference period. This is 0.09°C (0.16 °F) above the average for the past ten years (2004-2013)” (WMO, 2014). Fussel (2007) also notes that due to the accumulation of GHGs already in the atmosphere, the climate will continue to change regardless whether GHG emissions ceased today (Fussel, 2007). The effects of emission reductions have a significant lag time, meaning, the positive impacts will not be felt for many decades after the reductions are made. The impacts of adaptation are experienced at the local and/or regional scale, whereas mitigation requires collective global action. Last, Fussel (2007) describes the important ancillary benefits of adaptation, namely reducing climate-sensitive risks.

For the reasons identified by Fussel (2007), adaptation planning has become more mainstream in recent years. Local governments will necessarily be at the forefront of this work, as many of the impacts of climate change will affect infrastructure within their jurisdiction. The next section will elaborate on the process of adaptation planning and the importance of adaptation planning at the municipal level.

### **2.1.1. Municipal Adaptation Planning Opportunities**

Municipal governments provide services that reflect the needs and desires of their constituents. Under provincial legislation, municipal governments have the authority to provide, but are not limited to, the following services:

- General government
- Transportation – streets and roads, in some cases urban transit
- Protection – police, fire
- Environment – water treatment and supply, waste water treatment, refuse collection/disposal
- Recreation and culture – recreation centres, playing fields, parks, libraries
- Land use planning and regulation, building regulation, zoning
- Regulation – animal control, public health, signs, business licensing, municipal services (BC Ministry of Culture, Sport, and Community Development, 2014)

Climate change adaptation does not fit neatly into any one of these categories; however, local governments across Canada are stepping up to the challenge of addressing climate change at the local scale for two main reasons. First, the impacts of climate change are directly experienced at the local level (Richardson & Otero, 2012) and, therefore, adaptation responses must account for geographic variability and downscaled climate vulnerability analysis (Measham, et al., 2011). Second, the apparent lack of success at the international and national level to achieve meaningful reductions in GHG reductions has left municipal governments needing to prepare for anticipated climate impacts.

Municipal governments have three critical roles in climate change adaptation: develop adaptation responses to local impacts, mediate between individual and collective responses to vulnerability, and govern the delivery of resources to facilitate adaptation (Measham et al., 2011). Effective adaptation responses require strong leadership at the local level to ensure integration into the existing policy and planning processes (ICLEI, 2015). In addition, responses must be measurable, reflective, prioritized, and cost effective in the long term (Travers, Elrick, Kay, & Vestergaard, 2012).

In many respects, municipal governments already have the necessary tools to address climate change. Existing tools include Official Community Plans (OCPs), zoning bylaws, development permits, design guidelines, and master infrastructure plans. Despite these tools, barriers to adaptation at the municipal level remain. Barriers to adaptation in BC have been identified as

Uncertainty about the nature and rate of local climate change, and which climate parameters pose the greatest risk to continued safe and cost effective operation of existing and proposed infrastructure. The uncertainty extends to the design values [that] may not take future climate changes, particularly extreme climate events, [into account]. The unknown risks of climate change impacts to individual infrastructure components, and determining the adaptive capacity of these components. The development of effective knowledge and capacity among municipal staff to maintain infrastructure at a sustainable level of service that is resilient to climate change impacts (Feltmate & Thistlethwaite, 2012, p. 2-3).

Feltmate & Thistlethwaite (2012) recommend cities embrace a “no regrets” approach to climate policy and aim to improve infrastructure resilience and generate community benefits that extend beyond mitigating climate change impacts.

### **2.1.2. “No Regrets” Adaptation Planning**

Sustainable rainwater infrastructure is often used in the literature as a means to integrate green infrastructure into urban areas and receive multiple benefits from the infrastructure. Receiving multiple benefits from a single infrastructure investment allows planners, city officials, and engineers to implement “no-regrets” infrastructure. The idea behind “no-regrets” infrastructure for adaptation is that a single infrastructure investment will provide multiple benefits, which help to justify a certain type of adaptation infrastructure over another. For instance, implementing sustainable rainwater measures provides stormwater management, economic, social and environmental benefits, as well as acting as a climate change adaptation measure. Alternatively, “hard” infrastructure such as a reservoir to catch and store excess stormwater only provides stormwater management services and can prove expensive over the long-term due to maintenance costs and inability to efficiently be upgraded for increased storage capacity.

Adaptation planning typically incorporates “hard” and “soft” approaches. Soft approaches are usually employed first and refer to policy and behavioural changes (Clark et al, nd; Jones, Hole, and Zavalta, 2012). Hard infrastructure refers to manmade infrastructure, such as “dams, irrigation systems, reservoirs, dykes, seawalls, levees, river channelization, and rip-rapping (Clark et al, nd, pp. 16). Jones et al. (2012) considers EbA approaches the third category of adaptation approaches, as it requires a combination of both hard and soft approaches. As Jones et al. (2012) explains, “EbA [is] generally deployed in the form of targeted management, conservation and restoration activities, and are often focused on specific ecosystem services with the potential to reduce climate change exposures” (pp. 1).

There is tremendous opportunity to integrate EbA into adaptation planning by taking a “no-regrets” approach to adaptation as EbA strategies can be employed that not only support adaptation actions but provide for a more sustainable and livable city overall. In instances where an EbA approach may not provide a complete adaptation solution or where hard infrastructure investments have already been made but could use improvements or an adaptive capacity, EbA approaches may be included to complement hard infrastructure. Incorporating EbA into hard infrastructure approaches may increase the overall capacity of the infrastructure to cope with climate change (Jones et al., 2012). In regards to stormwater infrastructure, EbA solutions may provide a more cost effective solution to hard infrastructure, such as green infrastructure being less expensive to maintain than traditional stormwater infrastructure. Last, an EbA approach

may be the option to provide a no regrets approach to adaptation planning due to the benefits it provides at both temporal and spatial scales.

### **2.1.3. Canadian Infrastructure Deficit**

Canadian municipalities are currently experiencing an infrastructure deficit resulting from delays in upgrades and maintenance to municipal infrastructure (Hanniman, 2013; FCM, 2012; Mirza & Haider, 2003). The Canadian Infrastructure Report Card<sup>1</sup> assessed the condition of municipal infrastructure between 2009 and 2010. The report assessed drinking water systems, wastewater infrastructure, stormwater networks and roads in 123 municipalities across Canada. On average, 30% of the infrastructure assessed ranked between “fair” and “very poor.” The replacement cost of these assets alone totals \$171.8 billion nationally, or \$13,000 per Canadian household (Felio, 2012).

The report examined infrastructure service life under current practices (investment, operations, maintenance). Unfortunately, the report did not analyze the implications of future climate change projections. While we cannot be sure how the projected climate change impacts will impact the effectiveness and lifespan of current municipal infrastructure, the deficit may in fact be even more profound and the impacts of climate change and its associated costs will be more severe than currently anticipated. The results of this report card are nonetheless important as they indicate that municipalities are, or will be, working on upgrading infrastructure. If climate change is considered in new infrastructure designs, municipalities will likely benefit from taking an ecosystem-based approach, as natural systems are less expensive to build and maintain compared to hard infrastructure.

## **2.2. Ecosystem-based Adaptation (EbA)**

*Ecosystem-based Adaptation (EbA) uses biodiversity and ecosystem services as part of an overall adaptation strategy to help people and communities adapt to the negative effects of climate change at local, national, regional and global levels (UNEP, 2014).*

<sup>1</sup> Report created by the Canadian Society for Civil Engineering (CSCE), the Canadian Public Works Association (CPWA), the Canadian Construction Association (CCA) and the Federation of Canadian Municipalities (FCM).

EbA is a novel approach to planning and adaptation that prioritizes ecosystem services, enhancing biodiversity, as well as human health and wellbeing (Colls, Ash, & Ikkala, 2009). The concept developed from the connection between EBM and climate change adaptation actions. EBM is “an adaptive approach to managing human activities that seeks to ensure the coexistence of healthy, fully functioning ecosystems and human communities. The intent is to maintain those spatial and temporal characteristics of ecosystems such that component species and ecological processes can be sustained, and human wellbeing supported and improved” (Price et al., 2008). As described above, climate change adaptation are actions taken to reduce the negative affects or take advantage of new opportunities of climate change. EbA is a fusion of both of these EBM and climate change adaptation and remains relatively new in practice but is being deemed “a cost effective operational tool that can complement, if not substitute, traditional [hard] infrastructure practices” by the UNEP.

Traditionally, EBM is applied in resource management issues from forestry to fisheries practices. EBM is a planning approach that incorporates multiple issues into one management strategy, from individual species to whole ecosystem functions (Travers, Elrick, Kay, & Vestergaard, 2012). EBM is an innovative management regime because it acknowledges the rich complexity of ecosystems and attempts to identify, protect, and where necessary, restore important interactions. More specifically, EBM considers human activity in the specific management context and allows multiple activities to be managed for a common outcome (UNEP, 2012). EBM aims for a holistic approach to support an optimal management response (Travers, Elrick, Kay, & Vestergaard, 2012). When climate change adaption and EBM are practiced in tandem, the result should be a systems-based approach “that considers all relevant drivers and responses to change, including, climate-driven change, disaster risk response, climate variability, and broader long-term socio-economic change” (Travers, Elrick, Kay, & Vestergaard, 2012).

A main facet of EbA is the consideration of existing ecosystem services and how they are utilized for human wellbeing (Huq et al., 2013; Munang et al, 2013). Climate change adaptation in urban areas is increasingly concerned with protecting public and private assets from destructive climate change impacts. Ideally, through proactive planning, urban areas can utilize existing or restored natural systems to deliver ecosystem services that duplicate or complement hard infrastructure in mitigating climate change impacts.

In practice, EbA options will vary depending on the local context. Climate change will affect areas differently and local governments will need tailored solutions to utilize natural solutions. While climate change impacts and local contexts may vary, common themes are emerging from practice. In North America, EbA in urban areas is often implemented in the form of green and/or blue infrastructure, such as green roofs, bioswales, rain gardens, urban forests, wetland restoration, and green corridors. It is also common for literature to refer to green and or blue infrastructure as solutions resulting from an EbA approach.

### **2.2.1. Benefits of ecosystem-based adaptation**

The main advantage of EbA over other adaptation approaches is the delivery of multiple co-benefits to society (Munang et al., 2013). Emerging literature promotes EbA as applicable to both developed and developing nations (Munang et al., 2013). The co-benefits of EbA help achieve multiple policy and environmental objectives to address climate change. For example, protecting or restoring natural infrastructure such as barrier beaches, mangroves, coral reefs, and forests buffers human communities from natural hazards, erosion, and flooding (Munang et al., 2013).

The multiple benefits resulting from the foundational principles of the concept facilitate a systems-theory approach to adaptation planning. When adaptation work is approached too narrowly, it tends to produce infrastructure solutions that resolve one issue but may inadvertently cause many more. The development of new problems because of adaptation actions is referred to as mal-adaptation. Mal-adaptation is important to avoid in order to not waste time and resources. A basic example of mal-adaptation is using air conditioners to adapt to extreme heat. In most places, the energy to run an air conditioner is from burning fossil fuels, which emit GHG emissions, consequently exacerbating climate change. Alternatively, green roofs provide a cooling effect to a building through trans evaporation, as well as provide excellent insulation, allowing less cool air to escape the building, which consequently reduces the energy required to lower the temperature of the building.

To best illustrate the potential benefits of EbA, this section will explore the economic, environmental, and social benefits of green infrastructure as described by the literature. In order to understand the multiple benefits of EbA, we must look for the benefits of incorporating blue/green infrastructure in urban areas. A report by ARUP's Foresight and Research team identified the following social, economic and environmental benefits of green infrastructure.

Environmental benefits include “improved visual amenity, enhanced urban microclimate, improved air quality, reduced flood risk, better water quality, improved biodiversity, reduced ambient noise, and reducing atmospheric CO<sub>2</sub>” (ARUP, 2014, pp. 110). Economic benefits include “increased property prices, increased land values, faster property sales, encouraging inward investment, reduced energy costs via micro climate regulation, improved chances of gaining planning permission, improved tourist and recreation facilities” (ARUP, 2014, pp. 110). Social benefits include “encouraging physical activity, improving childhood development, improved mental health, faster hospital recovery rates, improved mental health, improved workplace productivity, increased social cohesion, and reduced crime” (ARUP, 2014, pp. 110).

The social, economic, and environmental benefits of EbA will be explored in more detail in the following sections.

### ***Economic Benefits***

The costs of climate change are real and increasing. *Paying the Price: The Economic Impacts of Climate Change for Canada* by the National Roundtable on the Environment and the Economy (NRTEE) estimated that the long-term financial impact of natural catastrophes will cost Canadians \$5 billion per year by 2020, and \$21-\$43 billion by 2050 (NRTEE, 2011). Literature and case studies on EbA indicate it constitutes a cost-effective adaptation approach. There are many areas to consider when exploring the economic benefits of EbA; however, this section will primarily focus on two: the value of ecosystem services to human wellbeing, and the impact on property values.

### **Value of ecosystem services**

Most simply put, ecosystem services are the direct and indirect benefits people obtain from ecosystems (Millennium Ecosystem Assessment, 2005). The Millennium Ecosystem Assessment (MEA) describes ecosystem services using four broad categories: “provisioning (direct), cultural (direct), regulating (indirect), and supporting services (indirect)” (Patterson and Coelho, 2009, pp. 1638; MEA, 2005). The services provided by ecosystems are often missing in policy decisions because they are difficult to quantify, as they are not captured in commercial markets (Costanza, 1997). The MEA (2005) identifies the following ecosystem services:

- Supporting services: Nutrient cycling, soil formation, primary production

- Provisioning services: Food, fibre, genetic resources, biochemical and natural medicines, fresh water
- Regulating services: air quality regulation, climate regulation, water regulation, water purification and treatment, erosion regulation, disease regulation, pest regulation, pollination, natural hazard regulation
- Cultural services: aesthetic values, spiritual and religious values, recreation and ecotourism (MEA, 2005, pp. 57).

In an effort to have ecosystem services considered more deeply in policy objectives, economists and ecologists have been working to quantify ecosystem services.<sup>2</sup> The estimated global value of ecosystem services is \$33 trillion per year (\$1994) (Costanza et al., 1997). Although it may not be feasible to calculate ecosystem services at the local level, municipalities could identify expected climate change impacts, associated ecosystem services that might mitigate specific impacts, and incorporate EbA approaches in adaptation plans. Even without the exact value of associated ecosystem services, a municipality could compare the cost of protecting, restoring, or implementing ecosystem-based solutions compared to hard infrastructure approaches. In other words, the value of ecosystem services could also be calculated through a cost vs. benefit analysis of different infrastructure options.

### **Increased Property Values**

The values of property within close proximity to green infrastructure, such as parks, are shown to be higher than properties further away from such infrastructure. Property values may also be increased when local amenities include green/blue infrastructure solutions that reduce the likelihood of property damage from some flood events (ARUP, 2014). A study of property values conducted in Australia indicates that houses close to parks average 1 to 8% higher price than similar properties further away (Mekala, 2014). The study shows “the net increase in property value in the 500m radius of the project area will range from \$2.27M (at 1% increase in

<sup>2</sup> It should be noted that monetizing ecosystem services is problematic for several reasons. For one, attaching an accurate dollar figure to ecosystem services is near impossible as all ecosystem services are hard to identify and any value placed on an ecosystem service is subjective. Similarly, a valuation of ecosystem services only gives value to human uses and not the biosphere as a whole. Last, as discussed by McCauley, a dollar figure commodifies nature in a dangerous way by placing it within the capitalist market system where conserving nature becomes incentivized for economic gains. If the ecosystem changes, those economic incentives may disappear along with the argument for conserving that area of land. With the commoditization of ecosystem services, we run the risk of undervaluing ecosystem services and overvaluing human made alternatives.

value over current median house price of the area) to \$18.15M (at 8% increase in value)” (Mekala, 2014, pp. 22). The increase in property values not only benefits the private property owner, but also results in increased tax benefits received by the local government as private property tax rates are based on the property value.

### ***Environmental Benefits***

The environmental benefits received from an EbA approach are derived from restoring or enhancing the ecosystem services that existed pre-development of the urban setting. In the sustainable rainwater context, the most significant aspect is improving the hydrological function of the land. That single improvement requires replacing pavement and pipe systems with natural drainage systems. These systems mimic the pre-development landscape and allow green infrastructure features to permeate the landscape to facilitate new drainage opportunities. Increasing the presence of green infrastructure features provides numerous additional environmental benefits to the surrounding area. Benefits include reduced urban heat island effect (UHI), improved air quality, reduced flood risk, improved water quality, improved biodiversity, and the avoidance of mal-adaptation (ARUP, 2014; Munang et al., 2013; Doswald & Osti, 2011).

### **Microclimate Regulation**

Through a phenomenon known as UHI, urban areas have markedly higher temperatures than the surrounding rural areas due to the materials in urban areas having a higher thermal capacity for heat storage, less vegetation, excess heat released from buildings, and the geometry of the City (Zhou & Parves, 2012). This results in higher energy use to keep buildings and vehicles cool, as well as an increase risk to residents of suffering from heat related illnesses. Due to the UHI, the average daytime air temperature of parks is an estimated 1°C cooler than the heat-absorbing built environment (Elmqvist, 2015; Zupancic, 2015; Bolund & Hunhammar, 1999). In fact, studies have shown in some cities, air temperature increase as one moves away from the vegetated area (Demuzere et al., 2014). Studies conducted in Singapore, Tel Aviv, and Stockholm not only show a decrease in temperature closer to vegetated areas but also a decrease in energy use (Demuzere et al., 2014; Bolund & Hunhammar, 1999).

The microclimate regulation of parks and large vegetated areas is the result of increased shading and enhanced evapotranspiration (Demuzere et al., 2014). City trees for example, lower temperatures by consuming 1000 MJ of heat energy to transpire 450L of water per day

(Bolund & Hunhammar, 1999). Domestic gardens and green roofs provide similar microclimate regulation and reduced energy use, as well as increase opportunities for rainwater retention. When planned strategically, domestic gardens can provide shade in the summer and reduce cold winds in the winter (Elmqvist, 2015; Bolund & Hunhammar, 1999). Similarly, when trees lose foliage in the winter, they allow more sun radiation into a home, which may then be circulated through internal ventilation.

### **Improved Air Quality**

Transportation, heating buildings, and industrial activities are significant contributors to air pollution in urban areas (Bolund & Hunhammar, 1999). The most common air pollutants include “particulate matter (PM), sulphur dioxide (SO<sub>2</sub>), ground-level ozone (O<sub>3</sub>), nitrogen dioxide (NO<sub>2</sub>), and carbon monoxide (CO)” (Zupancic, 2015). In Canada, 54 per cent of the population lives within 500 meters of a major road or highway (Zupancic, 2015). While it is widely reported that urban vegetation helps reduce air pollution, the exact reduction amount varies between species, temporal, and spatial variability (Elmqvist, 2015; Demuzere et al., 2014; Bolund & Hunhammar, 1999). Green areas in London are reported to remove 852 tons of PM<sub>10</sub> annually or in other words, a ten by ten km grid in London with 25% tree cover could remove 90.4 tons of PM<sub>10</sub> per year (Demuzere et al., 2014). Similarly, an analysis of ten US cities indicate that up to 64.5 tons of fine particles (PM<sub>2.5</sub>) are removed annually by urban trees (Demuzere et al., 2014).

### **Reduced Flood Risk**

Green and blue infrastructure in urban areas increase the opportunity to benefit from natural buffers to peak flows resulting in floods. Outside of the urban setting, forests, wetlands, and floodplains capture, slow, and store water reducing floods and recharging groundwater (Demuzere, 2014). Many urban areas, including much of Metro Vancouver, are built on floodplains, forests, and filled in wetlands. The natural buffers and processes that existed predevelopment are lost, and built areas are more vulnerable to damages, especially when climate change projections are taken into consideration. In addition, impermeable surfaces in urban areas result in 60% more runoff than vegetated areas (Demuzere et al., 2014). As precipitation patterns change with climate change, the risk of flooding in urban areas increases. Studies have shown well placed green and blue infrastructure with high infiltration capacity can

reduce 100% of stormwater runoff during normal precipitation years and 77-88% during high precipitation years (Demuzere et al., 2014).

Green roofs and bioretention cells have proven very capable of reducing peak flows of stormwater runoff in urban areas. For small to medium storm events, bioretention cells have shown a reduction of peak flows of 96.5% (Demuzere et al., 2014). Similarly, a study of green roofs in Germany indicated a reduction of runoff between 68 and 88 percent. The amount of runoff depended on the design and depth of the green roof, local climate conditions, and amount of event specific precipitation (Demuzere et al., 2014). While changes in precipitation resulting from climate change show an increase in large and frequent rain events in Metro Vancouver (Surrey, 2013), green infrastructure is better equipped to adapt to changing conditions in the future when compared to hard infrastructure solutions.

### **Improved Water Quality**

Forests, wetlands, and soils store, filter, and cool water before entering fish bearing streams and rivers (ARUP, 2014). When rain falls onto impervious surfaces, it traditionally travels through piped systems to the discharge point in a nearby watercourse. Studies have indicated that “[u]rban runoff was the primary source of impairment for 13% of rivers, 18% of lakes, 32% of estuaries, and 55% of ocean shorelines across” the United States (Odefey et al., 2012, pp. 28). Stormwater collects street pollutants and does not have the opportunity to be cooled or treated before being discharged. When stormwater is released into watercourses, the consistently polluted and warmed discharge disturbs the watercourse, which negatively affects the ecosystem. More specifically, elevated temperature and pollution make it difficult for fish species to survive and spawn (McGuire, 2010). Without taking action at the source via natural rainwater interventions, urban stream restoration efforts consistently fail to improve stream and water quality (Walsh, Fletcher, Ladson, 2005). In contrast, “grass bioretention cells remove nitrate/nitrite by up to 33%, phosphorus by up to 60% and fecal coliform by up to 100%” (Demuzere et al., 2014, pp. 110). In addition to removing pollutants, water temperature is also lowered, which is critical for fish bearing streams.

### **Improved Biodiversity**

The built environment removes vital ecosystems that enhance or maintain biodiversity in a region by providing habitat, food sources, and transportation routes for wildlife (ARUP, 2014; Munang et al, 2013; Doswald & Osti, 2011). Green and blue infrastructure may provide renewed

habitat, corridors, and food sources resulting in improved biodiversity (Munang et al, 2013). Enhancing biodiversity in urban areas is important for adaptation planning because areas with high biodiversity are more resilient to changes in climate and more adaptive over time (Doswald & Osti, 2011). Well-planned green and blue infrastructure, which is prevalent and well connected throughout the city, act as wildlife corridors so species can navigate the urban form safely (Rudd, Vala, & Schaefer, 2002).

The types of blue and green infrastructure that enhance biodiversity include green roofs, which create habitat for birds, insects, and microbes that feed native species (Seters, 2007). On the ground, green and blue infrastructure that parallels traditional wildlife corridors provides a win-win opportunity for urban areas to meet other goals, such as active transportation routes, rainwater management, reducing the urban heat island effect, or improve the streetscape. Strategies to enhance biodiversity can span beyond the public realm and get private property owners working to reach regional goals by planting native species in their backyard or restoring the ecosystem of power line right-of-ways (Rudd, Vala, & Schaefer, 2002).

The City of Surrey recognizes the importance of preserving, protecting and enhancing Surrey's biodiversity for the long-term. In 2014, Surrey released its Biodiversity Conservation Strategy (BCS) that "recognizes Surrey's biodiversity as a key foundation of a healthy, livable and sustainable community. Preserving nature (including plants, wildlife, and ecological values and functions) provides many benefits: clean air and water, improved health and liveability, reduced infrastructure, and aesthetic and recreational value (Diamond Head Consulting, 2014, pp. 4). This strategy is the result of an action outlined in the Surrey's Sustainability Charter (2008) (Surrey's research participant, Personal Communications, January 15, 2016). Included in both strategies is the importance of having a green infrastructure network, which includes parks, streams, biodiversity corridors, hubs, and sites (City of Surrey, 2013a).

### **Overcoming Mal-adaptation**

Mal-adaptation occurs when an adaptation action results in negative impacts to the ecosystem or results in increased GHG emissions. Two common examples of mal-adaptation are the use of sea walls to adapt to sea level rise and the use of air conditioning in urban areas to adapt to hotter summers and increased urban heat island effect. Building sea walls to adapt to climate change is an example of a hard infrastructure solution. Many places around the world have either built or are considering building sea walls to provide protection against raising sea

levels. In tropical regions, sea walls often result in the loss of mangroves (Clark et al, nd). Sea walls are well cited to increase beach erosion and degradation of the sea wall itself, which results in increasing costs to maintaining the sea wall over time (Clark et al, nd). Conversely, mangroves provide a natural buffer to rising sea levels, while providing important habitat for “birds, mammals, fish, crustaceans, shellfish and reptiles (Clark et al, nd, pp. 42). In addition, as a living ecosystem, mangroves provide important adaptation solutions as they can move inland as sea levels rise and continue to provide a buffer to storm surges by capturing wave energy during extreme storm events. While mangroves may not be able to protect from the largest storm events, they cost little to maintain and will continue to provide multiple services so long as they are not impeded from moving inland as sea levels rise.

Green roofs and living walls provide many benefits in urban areas including helping cities avoid mal-adaptation. As cities become warmer, energy costs will increase, especially if air conditioning use increases to make the urban environment more comfortable. In colder winter months, green roofs also provide superior insulation than traditional roofs resulting in reduced energy use for heating (Seters, 2007). Many studies have demonstrated the energy cost savings associated with green roofs. Seters outlined the following studies:

Monitoring by the National Research Council indicated a 75% reduction in energy demand for space conditioning in the spring and summer on a field roofing facility in Ottawa (Liu, 2002). Energy modelling conducted by the City of Waterloo (2004) for a 17,222 ft<sup>2</sup> extensive green roof on a one-storey office building indicated annual savings of \$400 and \$554 in heating and cooling energy costs, respectively. Martens and Bass (2006) reported significantly greater energy savings associated with roof greening for single story buildings than for 2 or 3 story buildings. During a July day in Toronto, a green roof with dimensions of 820 ft by 820 ft was found to bring about energy savings of 73%, 29%, and 18%, for 1, 2, and 3 story air conditioned buildings, respectively (Seters, 2007, pp. vii).

Reducing energy use in urban areas will be key for climate change mitigation measures. Not only do green roofs reduce energy use, but the vegetation also sequesters carbon out the atmosphere. This means that green roofs provide both adaptation and mitigation actions against climate change.

### ***Social Benefits***

In addition to economic and environmental benefits of EbA, there is tremendous opportunity to improve the social experience of residents living in close proximity or visiting green spaces in urban areas. The value of green spaces and intact ecosystem for residents are numerous and widely cited in the literature (Elmqvist, 2015; Zupancic, 2015; Demuzere et al., 2014; Zhou & Parves, 2012; Bolund & Hunhammar, 1999). In addition, when taking a ‘no

regrets' approach to planning, providing increased social benefits to communities, in addition to improved stormwater management and resilience to climate change, is a win-win for municipal governments. Green spaces without a doubt shape the urban landscape and have a great influence over how residents interact with the urban form. The subsequent section will elaborate on the following social benefits of green infrastructure: promoting physical and mental health, aesthetic and cultural values, and educational opportunities. (Zhou and Parves, 2012;).

## **Health**

Enhanced physical health is a social benefit resulting from access to green urban areas. The social benefits received are twofold. First, improved access to green space, the quality of the area accessed, and quantity of urban green spaces provide the opportunity for increased recreational opportunities. This can be in the form of organized or informal sports, playing, walking, relaxing, or using the green space as an active transportation corridor. Recreational values can also include the presence of wildlife, such as birds and fish. In Stockholm for example, a central urban stream is home to over 30 species of fish and is considered one of the best fishing spots in the entire country (Demuzere et al., 2014). Similarly in Metro Vancouver, the return of Salmon to urban streams is a goal of stream restoration. Molnar (2011) argues that recreational opportunities, whether play or rest are "perhaps the highest valued ecosystem service in cities" (pp. 18).

Green infrastructure encourages and supports active transportation methods, such as walking and cycling (Bolund & Hunhammar, 1999). Active transportation has benefits for the individuals engaging in the activity but those benefits are also experienced at many scales. For instance, the surrounding region will experience improved air quality, less noise pollution, a decrease in traffic, and less maintenance to road infrastructure. At a larger scale, fewer cars will result in a reduction in GHG emissions from transportation. Last, studies have shown that cities with more commuters using active transportation methods result in reduced costs to the healthcare system and a decrease in certain diseases, such as heart disease and diabetes (Bolund & Hunhammar, 1999). In addition, studies have found a positive correlation between hospital patients healing faster and needing less pain management when rooms faced a park compared to patients that had rooms facing other buildings (Demuzere et al., 2014). In other words, even without being physically present in the green space, having visual of green spaces has positive effects on healing and patient recovery.

In regards to a no regrets approach, cities are often finding multiple uses for green infrastructure; such as a combination of active transportation route, green spaces, and flood resilience infrastructure. For example, the Cowichan Valley Regional District expanded and rehabilitated a diking system in the region to increase safety and mitigate flood events from occurring just below the Trans Canada Highway. The new diking system is in response to a severe flood event in 2009 that affected 273 people and cost the region approximately \$1.5 million in damage (CVRD, 2014). The new system design considers projected increases in precipitation and responds to the likelihood of similar flood events happening once every seven years. The new dike provides multiple benefits to the community, including an active transportation trail, habitat for species at risk, and 35,500 m<sup>3</sup> of new fish habitat (CVRD, 2014).

### **Reduced Heat Related Illnesses**

Another positive of a no regrets approach to adaptation planning through green infrastructure is the benefit received by reducing the UHI effect. Studies from Toronto show that for every one degree Celsius increase in highest daily temperature and mean temperature, ambulance calls for heat related injuries increase by 29 and 32 percent, respectively (Zhou & Parves, 2012). The role of green infrastructure to reduce heat related illnesses and reduce the UHI effect is twofold. First, during extreme heat events, residents will seek refuge from the heat in shaded areas and water features in parks. Secondly, as discussed in the environmental benefits section, vegetation in urban areas cools the surrounding air through evapotranspiration.

### **Improved Mental Health**

Access to green spaces not only improves the physical wellbeing of residents but also improve their psychological wellbeing through providing an opportunity to unwind and relax through leisure and social activities. Studies have shown there is a strong connection between the “need for restoration (to reduce worries and stress), the use of environmental self-regulation strategies (favourite places), and restorative outcomes” (Demuzere et al., 2014, pp. 110). Studies have shown that exposure to nature and/or natural setting decreases stress symptoms; whereas, exposure to urban settings maintains or increases stress. Not everyone has access to a garden; therefore, public green spaces are important for the social benefit to be received and accessible to all residents. Given the tremendous benefits to a community’s physical well being, the social benefits received by green spaces should not be underestimated by planners, engineers, and community leaders.

In addition to improving mental health through leisure and social activities, studies have shown green infrastructure provides a passive benefit to mental health by reducing noise pollution in urban areas. Noise pollution from traffic, construction, and other sources is linked to health problems, such as stress in urban areas (Demuzere et al., 2014). Part of the problem is the source of the noise; however, the noise itself is unavoidable when living in an urban area. The other half of the problem is the built environment. Sound easily carries over a hard surface such as cement. Sound is decreased by 3 dB(A) as the distance away from the source doubles; a soft ground, such as grass, will decrease the noise by an additional 3 dB(A) (Demuzere et al., 2014). Similarly, shrubs, hedges, and trees continue to decrease the transfer of noise; however, the specific amount depends on many factors. Lastly, in addition to reducing noise pollution, increased vegetation, especially evergreen foliage, reduces “visual pollution” of traffic, thus reducing the overall disruption of traffic in urban areas.

### **Educational Opportunities**

Lastly the opportunity for education is a social benefit received by green spaces in urban areas. At an individual scale, taking part in a community gardening initiative allows someone to experience first hand the connection between the local ecosystem and growing vegetation or food. Without first hand experience, it may be difficult to have the same understanding of the local ecosystem and the importance of personal or societal actions that can be taken to mitigate or adapt to climate change (Demuzere et al., 2014). Similarly, as cities take a no regrets approach to adaptation planning, they learn what actions result in increased resilience to climate change and what areas still need to be improved. For example, after Hurricane Sandy produced widespread damage and major flooding in New York City, the City is now taking actions to improve resilience and reduce flooding in future events. Some actions to increase resilience include building park spaces along the waterfront in areas that were flooded during Hurricane Sandy. The aim is to have the park slow and store floodwaters and protect property from future flood events (City of New York, 2007).

## **Chapter 3.**

# **ISMPS AND CLIMATE CHANGE CONTEXT IN METRO VANCOUVER**

The following section examines rainwater planning at the watershed scale in the BC context, particularly the transition from viewing rain as stormwater to seeing it as a resource. To do so, urban planning and low impact development is first explored to provide a context for ISMPs. The next section explores the development of ISMPs in BC and the Water Balance Method employed through ISMPS. The legislative context for ISMPs in BC is then explained and the last section provides climate change projections for BC.

### **3.1. Urban Planning and Low Impact Development**

Urban planning as a field developed to mitigate problems associated with urban growth and development. As concern for the environment and public health in cities grew over time, development practices evolved to address actual and potential deterioration of the natural environment caused by decades of population growth, urban renewal and sprawl (Hodge and Gordon, 2008). In 1987, the *Report of the World Commission on Environment and Development: Our Common Future* defined sustainability and developed the concept of sustainable development. In the 1990s, the connection between land use decisions and environmental degradation became obvious in urban areas and the concept of Low Impact Development (LID) emerged as a form of sustainable development that addressed concerns of negative impacts to waters receiving urban stormwater. Academics, practitioners, and planners regard LID as the sustainable solution for stormwater management in urban areas.

LID practices are “micro-scale control practices used to bring the natural hydrology of a site close to that of its pre-development conditions” (Ahiablame, Engel, and Chaubey, 2013, pp. 151). The four fundamental hydrologic considerations of LID are: control of runoff volume, control of peak runoff rate, control of flow frequency/duration, and control of water quality

(Ahiablame, Engel, and Chaubey, 2013). Some LID practices include green roofs, permeable pavement, rain gardens, bioswales, and retention ponds (Qin, Li, and Fu, 2013). In other words, LID aims to capture, infiltrate, and store rainwater and thus slow the rate at which rainwater moves across the land to the receiving waters. LID solutions are implemented in urban areas through green infrastructure techniques. Municipalities in BC, such as the City of Surrey, implemented LID techniques for sustainable stormwater management prior to the publication of BC Stormwater Planning Guidebook (The Guidebook) in 2002 (Surrey's research participant, Personal Communications, July 6, 2015). This guidance document, founded on BC case study experience (including that of the cities of Surrey and Coquitlam), formalized a science-based understanding to set performance targets for reducing rainwater runoff volumes. The Guidebook prescribes desired outcomes for sustainable rainwater management at the watershed scale through the development of ISMPs.

### **3.2. Integrated Stormwater Management Plans: BC's Context for Innovative Stormwater Management**

Salmon stocks declined along the west coast of BC throughout the 1990s and the relationship between aquatic habitat loss, declining watershed health and inadequate fisheries management practices became evident (Lackey, 2000; Healey, 2009). A major contributor to aquatic habitat loss was the change in land use practices from human settlement and population growth across BC (Stephens, 2012). Human development and land use decisions buried, polluted, and eroded headwater streams throughout the province, destroying critical habitat for spawning salmon (Stephens, 2012). The decline of the iconic species became a warning sign that watershed health was degrading and, in turn, catalyzed the province to take action (Stephens, 2012).

Developed by an Inter-Governmental Partnership as an extension of the Guidebook, and launched in 2003, the "Water Balance Model" (WBM) scenario comparison and decision support tool is the outcome of a multi-year building block process that had its genesis in the late 1980s. Model development and evolution has depended on the long-term commitment of numerous partner organizations (federal, provincial and local), in particular the City of Surrey, which was a key player on the original steering committee that brought the tool from vision to fruition. Organizational commitment made it possible for champions within the partner organizations to provide guidance and input during development of a series of deliverables that have

successively been advancing the practice of rainwater management within BC. A decade ago, for example, the City of Surrey's *Fergus Creek Watershed Plan*, was the pilot for development of the stream health methodology that is embedded in the WBM engine. Currently, the cities of Surrey and Coquitlam continue to play leadership roles by demonstrating application of the "WBM Express for Landowners" ([waterbalance.ca](http://waterbalance.ca) website; Kim Stephens, Personal Communications, January 15, 2016).

The original driver for WBM development was UniverCity, the sustainable community that is built adjacent to Simon Fraser University atop Burnaby Mountain. Translating high expectations for this "green" development into practical design guidelines meant revisiting accepted drainage engineering practice; this need for innovation led directly to development of the WBM. The high expectations were established through the Brunette River Basin Plan and Stoney Creek ISMP processes in the 1990s. At the time, the Stoney Creek ISMP was characterized as a "pilot within a pilot".

In 2001 the Stormwater Interagency Liaison Group (SILG), a Metro Vancouver technical committee, recognized the value of the water balance approach and funded the development of a working model to assess the affordability and feasibility of site design solutions for achieving performance targets.

In July 2002 the Inter-Governmental Partnership was formed to develop the WBM as an extension of the Guidebook. It began as a subgroup of SILG and quickly expanded to become a provincial group with municipal representation from four regions: Metro Vancouver, the Fraser Valley, Vancouver Island and the Okanagan Valley.

By 2010, ensuring the legacy of the WBM by means of a legal entity was a governing consideration that resulted in the incorporation of the Partnership for Water Sustainability in BC as a not-for-profit organization (Kim Stephens, Personal Communications, January 15, 2016).

In summary, the historical relevance of the Stoney Creek ISMP is that it was characterized as "the pilot within a pilot", it established the environmental management expectations for UniverCity, those expectations were achieved through development of the WBM and the SILG embraced the water balance approach. The majority of Metro Vancouver municipalities were founding partners in the WBM initiative and continue to fund maintenance and evolution of the tool (Kim Stephens, Personal Communications, January 15, 2016).

## ***Brunette River Basin Plan***

Metro Vancouver, previously known as the Greater Vancouver Regional District, worked with five member municipalities: Vancouver, Burnaby, New Westminster, Coquitlam, and Port Moody, to develop the Brunette River Basin Plan (Stephens, Graham, & Reid, 2002). This plan was one of the first in the province to create an “agreed on vision, goals and objectives for catchments within the Basin” (Stephens, Graham, & Reid, 2002, 9-5). The vision, goals and objectives outlined in the Brunette River Basin Plan were applied through the Stoney Creek ISMP, the precedent setting pilot ISMP case study (Stephens, Graham, & Reid, 2002).

Stoney Creek’s headwaters, as well as Eagle Creek and Silver Creek headwaters, are atop Burnaby Mountain, in Burnaby, BC. The success of the Stoney Creek ISMP established a provincial precedent for applying the seven steps of watershed scale planning at the site level (Stephens, Graham, & Reid, 2002). The pilot study tested the watershed-based approach to integrating stormwater management and riparian corridor restoration (Kerr Wood Leidal- CH2M Hill, 1999). Stephens, Graham and Reid (2002) explain Stoney Creek, a salmon bearing stream, was selected as the pilot ISMP site because it “has the highest value aquatic resources; these resources are at risk due to pending residential development in the Burnaby Mountain headwaters; plus it has an active and proactive stream keeper group” (p. 9-5). The process piloted by the Stoney Creek ISMP established a philosophy and hydrologic criteria to protect and restore the watershed over a fifty-year timeline (Stephens, Graham, & Reid, 2002). The Stoney Creek stream keeper group conducted community-science that provided an aquatic habitat rating for each creek on Burnaby Mountain (Stephens, Graham, & Reid, 2002).

The success of the Stoney Creek ISMP signified a paradigm shift in stormwater management in BC (Stephens, 2012). Stormwater management is no longer about treating runoff after it accumulates in man-made infrastructure, but rather treating rainwater where it falls. Treating rainfall where it falls requires a science-based understanding of how rainfall would naturally move before human development. The Stoney Creek ISMP piloted the building blocks of the science-based rainwater management strategy, which includes: “rainfall (precipitation); the ability of the landscape to absorb rainfall; movement of water through the ground; and the resulting flow in streams” (Stephens, 2012, pp. 3). Capturing rainfall at the source ensures rainwater is absorbed back into the ground, reduces stormwater runoff volumes and protects downstream habitat as the ground cools and filters rainwater before it enters the river system.

Supporting and enhancing the action of rainfall to infiltrate, filter and enter the stream through the process of interflow<sup>3</sup> as opposed to a pipe, restores the natural water balance of the site.

### 3.2.1. The Water Balance Method (WBM)

The WBM was first created and implemented in BC to ensure a *no net loss of fish habitat* as a result of the salmon crisis. The WBM is applied to translate a science-based understanding of the relationship between rainfall and stream health protection into a watercourse management plan. The WBM is founded on the Rainfall Spectrum concept; this methodology accounts for all the rainfall-days in a year and links the rain that falls on a site, to the runoff leaving the site, and to the water flow in a stream (Kim Stephens, Personal Communications, September, 2014). The methodology is also the science-based foundation for developing any Master Drainage Plan, an ISMP, the Rainwater Management Component of a Liquid Waste Management Plan, or a Watershed Blueprint (Kim Stephens, Personal Communications, September, 2014). The methodology is translated into practice through an easily accessible, web-based scenario comparison tool, named the Water Balance Model.

The considerations that underpin the WBM are time (i.e. how long it takes for the water to be absorbed into the ground) and the idea that water is always moving. These two points underpin the WBM because land development fundamentally changes the ability for the ground to naturally absorb rainwater and increase the rate at which rainwater moves off the land. The key objectives of the WBM are monitoring and maintaining flow volume and flow rate (Stephens et al., 2002). Maintaining a set *flow volume* reduces the surface runoff volume, which in turn prevents the erosion of streams and supports the season base flow of the stream (Stephens et al., 2002). This is important for maintaining a healthy stream ecosystem and fish-spawning habitat. *Flow rate* is the rate at which surface runoff travels; by reducing the flow rate, stream erosion and the risk of flooding may be reduced (Stephens et al., 2002). Monitoring and maintaining the flow volume and rate objectives are the basis for the water balance approach to stormwater management.

<sup>3</sup> "Interflow is the portion of rainfall that infiltrates into the soil and moves laterally until intercepted by a stream or channel. For a fully forested area, there is virtually no surface runoff. The flow that we observe in streams is actually interflow" (Stephens et al., 2012, p. 8).

### **3.2.2. Legislative Context in Metro Vancouver**

On May 30, 2011, the then BC Minister of Environment, Terry Lake, approved Metro Vancouver's *Integrated Liquid Waste and Resource Management* plan (the Plan). In the Minister's note approving the Plan, member municipalities are required to complete the ISMP process. The note states:

Member municipalities will, with MV planning and coordination, and to the satisfaction of the Regional Manager, develop a coordinated program to monitor stormwater and assess and report the implementation and effectiveness of Integrated Storm Water Management Plans (ISMP). The program will use a weight-of-evidence performance measurement approach and will report out to the Biennial Report. The Regional Manager may extend the deadline for completion of ISMP by municipalities from 2014 to 2016 if satisfied that the assessment program could result in improvement of ISMP and protect stream health.

Metro Vancouver is the only region in BC to have a ministerial note requiring all member municipalities to develop ISMPs. The benefit for member municipalities to have such a requirement is that they can borrow money to develop and implement their ISMPs without gaining public consent first. As ISMPs are time and resource intensive, having the ability to borrow money easily removes a large barrier for member municipalities. Whether or not a member municipality actually borrows money to develop and implement their ISMPs will largely depend on the debt culture of the member municipality.

### **3.3. Metro Vancouver Climate change Projections and Impacts**

The Pacific Climate Impacts Consortium's (PCIC) Plan2Adapt online tool predicts an annual average increase in temperature of +1.7 °C and an annual increase in precipitation of +7% (+6% in the winter; -15% in the summer) for the greater Vancouver region for the year 2050. In addition to climate change projections, PCIC's Plan2Adapt tool also provides climate change impacts that local governments in Metro Vancouver should consider. The two impacts most pertinent to stormwater management are possible flooding, resulting from increases in precipitation, and increases in hot and dry conditions, resulting from increases in temperature. PCIC states: "Stormwater design standards may no longer be adequate. Combined sewer overflows may become more frequent. Natural area parks with stream and creeks may flood requiring greater local budget to manage storm water" (PCIC, 2015).

Increases in hot and dry condition impacts may be mitigated through ecosystem-based adaptation design principles. For example, some impacts expected from hot and dry conditions include:

- “Increased possibility of water shortages in summer and early fall...Regional and on-site water storage may need improvement or expansion” (PCIC, 2015).
- “Possible thermal stress on fish and habitat...Conservation status of fish species and ecosystems should be reviewed” (PCIC, 2015).
- “Heat island effects may become more problematic. Consider tree planting for mitigation of heat island effects, and to improve streetscape” (PCIC, 2015).

## Chapter 4.

### METHODS

Through select case studies in Metro Vancouver, I evaluated municipal ISMPs for the inclusion of EbA principles. The specific case studies evaluated for this research were the City of Coquitlam's *Partington Creek IWMP*<sup>4</sup> and *Nelson Creek IWMP*, and the City of Surrey's *Ocean Bluff/Chantrell Creek ISMP* and *Upper Serpentine ISMP*. I utilized the case study method for the research because it allowed for an in depth focus of the specificities of each case study site, which resulted in rich data and detailed comparisons between cases (Babbie and Benaquisto, 2010). This is an advantage for this particular research project because EbA is a relatively unknown concept and the more details and nuances that can be identified within the case studies allows for a greater understanding of EbA's application in urban areas and its identifiable implementation through ISMPs. The trade-off within the case study method is between breadth and depth (Babbie and Benaquisto, 2010). By only examining four ISMPs from two different municipalities, I was able to gather in-depth information about Surrey's and Coquitlam's ISMPs; however, I have no specific information on ISMPs from other member Metro Vancouver municipalities. The alternative could have been the collection of less detailed information on more ISMPs from other member Metro Vancouver municipalities. For this research project, the case study method was preferable as the relationship between ISMPs and EbA is explored in immense detail, allowing for detailed results about EbA principle implementation in urban areas and climate change adaptation.

To prevent problems of construct validity and reliability, I examined multiple sources of data to discover converging lines of inquiry that support convincing and accurate results. For

<sup>4</sup> As described in the introduction, ISMPs may also be referred to Watershed Blueprints or Integrated Watershed Management Plans. The City of Coquitlam refers to their plans as Integrated Watershed Management Plans (IWMPs). This paper will use the term IWMPs when referring to Coquitlam's stormwater plans; however will continue to use ISMPs as the general catch all phrase for IWMPs, ISMPs, and Watershed Blueprints.

instance, I initially completed an in-depth literature review of EbA, adaptation planning, policy and planning documents, EBM, and sustainability planning. I used the initial literature review to create an evaluative framework to identify EbA principles within ISMPs and broader planning and policy document. I used the evaluative framework to first assess ISMP specific documents, meaning they are the ISMPs created and used in either Surrey or Coquitlam. I then evaluated non-ISMP documents, which are related to either developing ISMPs, implementing ISMPs, or relate to the objectives of ISMPs or climate change adaptation but are not specific ISMP documents. The multiple sources of evidence I used for data collection include: academic literature, ISMP documents, policy and guiding documents from the municipal, regional and provincial scale, and interviews. The converging lines of inquiry for this research resulted from ISMP design guidelines and best practices; academic literature about the principles of EbA and implementation strategies; climate change adaptation principles; and foundational EBM principles.

The decision to evaluate four case sites resulted from financial and temporal constraints, as well as the expectation that not every possible case site in Metro Vancouver would be feasible to evaluate in this study. In addition, local governments use the same provincial guidebook to develop their ISMPs; thus, they should be implementing similar holistic principles, however, results vary as local governments have complete autonomy over the ISMP process.

The research was conducted in four stages:

1. Literature Review
2. Expert Interviews
3. Evaluation
4. Analysis

The following section will explore each research stage in the order it was conducted.

## **4.1. Literature Review**

To complete the literature review, I examined EbA literature, ISMP guiding documents, climate change adaptation and mitigation literature, green infrastructure literature, ecology literature, as well as stormwater and rainwater best management practices. I used NVivo software to code documents to find similar themes, practices, and categories within and across

documents. Coding is the process of classifying data so that it can be analyzed (Strauss & Corbin, 1990).

NVivo is organizational and analytical software for qualitative research (Bazeley & Richards, 2010). The etymology of the word NVivo is “in vivo,” which means live from the text (Bazeley & Richards, 2010). “In vivo coding” is a particular kind of coding derived from grounded theory.<sup>5</sup> For “in vivo coding,” the researcher “codes” for certain words, themes, or passages that are relevant and interesting to the research project, coding every time the word, concept, phenomenon, idea, explanation, or activity appears in the text, and sorting evidence and sources according to its context. If “in vivo coding” is done rigorously, the researcher should be able to analyze how the word occurs throughout the literature and the different meanings attributed to the particular word (Bazeley & Richards, 2010). Since I was more interested in specific concepts and how they relate, I utilized “concept driven” coding techniques in my research.

Concept-driven coding is when the codes are derived from “the categories or concepts [identified in] the research literature, previous studies, topics in the interview schedule, hunches you have about what is going on, and so on” (Gibbs, 2007, pp. 44). The literature review was instrumental for developing the evaluative framework described below, which resulted in the development of indicators that informed the concepts that were later coded for in the documents. NVivo software also allowed me to sort documents by author, publication year, scale of application (municipal, regional, provincial), document type (policy, planning, guiding, ISMP), location (Partington Creek, Nelson Creek, Ocean Bluff/ Chantrell Creek, Upper Serpentine). Sorting concepts in novel ways helped me to understand the context in which the data was created, the audience for whom it was written, and the progression of concepts through time (Yin, 2003).

### ***Developing the Evaluative Framework:***

Building from the results of the literature review and additional research on evaluation framework design, I developed an EbA evaluative framework. I developed the first draft of the

<sup>5</sup> Grounded theory denotes theoretical constructs derived from the qualitative analysis of data (Corbin and Strauss, 2008). In other words, it is the process of observing a phenomenon and deriving a theory based on the analysis of qualitative evidence. The process requires the researcher to remain unbiased and allow the theory to evolve from the “ground” (evidence) as opposed to using a hypothesis to guide the collection of data.

framework by expanding on the work of Huq, Renaud, and Sebesvari (2013), particularly by incorporating ISMP specific indicators and exploring academic literature on EbA published after Huq, Renaud, and Sebesvari (2013). Huq, Renaud, and Sebesvari (2013) provided a great starting point for developing the evaluative framework for this research because they completed a systematic literature review of EbA principles to date. Much of the literature they identified is foundational work on EbA. After reviewing Huq, Renaud, and Sebesvari's (2013) sources, I was able to work forward and review new literature published after 2013. Huq, Renaud, and Sebesvari (2013) identified the following principles and associated indicators:

- *Flexible management structure: Adaptive management approaches; incorporated clear planning principles; promote existing best resource management; community based management*
- *Knowledge based adaptation: build knowledge and awareness; local science-management partnerships; best available science and local knowledge; culturally appropriate*
- *Maximum stakeholder involvement: maximum stakeholders, involving local communities; multi-partner strategy; collaboration and trust*
- *Variety: Work with uncertainties; explore and prioritize climate change impacts; explore a wide variety of climate change impacts; explore a wide spectrums of climate change options; understanding tradeoffs*
- *Multi-scale operation: integration with development strategies; support sectoral adaptation planning; multi-sectoral approaches; multiple geographic scales*
- *Ensuring Governance: accountable; transparent decision-making; gender balancing; equity; monitor and evaluate systematically*
- *Resilience building: resilience vs. resistance; manage climate variability; manage long-term climate change; reduce DRR vulnerability; reducing non-climate stresses*
- *Maintaining ecosystems: promote resilient ecosystems; maintain ecosystem services; enhancing biodiversity; resource conservation; avoid mal-adaptation*
- *Integrating development: providing social, economic and environmental benefit; enhancing livelihood support; cost effectiveness (Huq, Renaud, & Sebesvari, 2013, pp. 4).*

After attaining a comprehensive understanding of EbA, adaptation planning, and sustainable stormwater management, I then turned my focus on reviewing evaluative framework methodologies. I discovered the work of Baynham and Stevens (2014), which became instrumental in the design and analysis strategy employed in this research. It was through this

thorough literature review of foundational work and evaluative framework methodologies that I developed the principles, indicators, and indicator descriptions of the final evaluation framework (Table 1). Before conducting the evaluation, I ground truthed the evaluative framework for its applicability to ISMPs through expert interviews.

## 4.2. Expert Interviews

I used a semi-structured interview style to conduct expert interviews with research participants from the City of Coquitlam and the City of Surrey. Semi-structured interviews are “sufficiently structured to address specific topics related to the phenomenon of study, while leaving space for participants to offer new meanings to the study focus” (Galletta and Cross, 2013, p. 45). Semi-structured interviews were appropriate to answer my research questions because they are less formal in structure, which allowed research participants to draw on personal experience while also addressing theoretical concepts of interest (Galletta and Cross, 2013).

To develop the evaluative framework (see Table 1 below), I utilized *expert-led and top-down* methodology and as opposed to *bottom-up and community-based* methods. Expert-led approaches rigorously collect data from academic literature and expert informants (Reed, Fraser, Dougill, 2006). The principles and indicators utilized in the evaluative framework were adapted from the work of Huq, Renaud, & Sebesvari (2013); Brody (2003); and Baynham and Stevens (2014). The principles and indicators were selected based on their relevance to the urban context. The description of each indicator was identified through a literature review of EbA guidebooks and peer-reviewed papers, and then adapted to be applicable to the urban context. The method for developing the framework was based on the work of Baynham and Stevens (2014).

Despite the strengths of using both bottom-up and top-down methodology when developing evaluative frameworks, I decided not to employ bottom-up, community-based approaches due to the scope of the project and the lack of public knowledge about EbA (Reed, Fraser, Dougill, 2006). The scope and timeframe of the project would not allow for in depth community consultation on the principles and indicators used in the evaluative framework. What’s more, EbA is a relatively new concept and the average citizen will likely not have enough knowledge about the concept to meaningfully engage.

I conducted semi-structured interviews with key informants over the phone in two phases. In the first phase of interviews (known as the pre-interview), I interviewed key contacts at the City of Coquitlam and the City of Surrey to introduce the research project and research questions, to explain the ethics procedure, discuss the evaluative framework, select case study sites, and identify required documents. The second phase of interviews drew on the expertise of the research participants and to present the initial results of the evaluation. The second phase was integral for filling in any gaps in the evaluation by discovering information that was not explicitly mentioned in the ISMP documents. The second round of interviews also provided the opportunity for the experts to review the results of the evaluation of the ISMPs. The second round of interviews also allowed the experts to add any additional information to the research that related to the evaluation and provide a rationale for why the ISMP may have scored the way it did. The interviews were recorded and transcribed.

The interview process was an integral step of the research project as it not only assisted in developing a rigorous framework that was used to complete the assessment, but the responses from the research participants helped to find converging lines of inquiry, confirm construct validity, and confirm reliability of results. As I only interviewed professionals knowledgeable about the research subject, there was a low risk of undermining ethical requirements. I gained *Simon Fraser University's Ethics Approval* before conducting interviews to ensure research objectives were adequately communicated to research participants and privacy remained protected (Spradley, 1979).

### **4.3. Evaluation**

To evaluate ISMPs for the inclusion of EbA principles, I developed an evaluation framework to assess each document (see *Developing the Evaluative Framework* section above). Both ISMPs and non-ISMPs were evaluated using this framework. All documents were coded using NVivo software based on concept driven coding, as described above. The principles and indicators in the framework informed the nodes and acted as the criteria each document was coded against. The explanation of each indicator acts as a definition of the code, which describes the nature of the node, the thinking behind it, explains how the code should be applied, and the concepts linked to the code (Gibbs, 2007).

## Evaluative Framework

The following evaluation scheme was used to quantify if and how EbA principles are implemented in Metro Vancouver through ISMPs. It also identified areas for improvement. The analysis criteria were adapted from the work of Baynham and Stevens (2014).

**Table 1: Evaluative Framework**

Principles	Indicators	Description
<i>Fact Base</i>		
Knowledge Based Adaptation	Climate Change As An Issue	If climate change is framed as an issue facing the local or global community (Baynham and Stephens, 2014).
	Impacts Of Climate Change	If the ISMP identifies the expected impacts specific to the municipality (Baynham and Stephens, 2014).
	Vulnerability Assessment	If the ISMP identifies impacts of climate change as a rationale for implementing the ISMP (Baynham and Stephens, 2014).
	Best Available Science	If the ISMP identifies scientific evidence for land use, soil and drainage, ecology, flood management, water quality, wildlife habitat, watershed mapping, and sensitive ecosystem identification.
	Local Climate Change Projections	If the ISMP references local/regional climate change projects in planning and design documents.
<i>Goals</i>		
Address Climate Change	Adaptation	If the ISMP has broad or general goals related to adaptation or reducing vulnerability to climate change (Baynham and Stephens, 2014).
Multi-scale Operations	Integration With Development Strategies	If ISMP identifies or is incorporated into a broader planning strategy in the region.
	Sectoral Adaption Planning	If the ISMP utilized the expertise of planner, engineers, and scientific experts, such as ecologists (Colls et al., 2009).
	Multiple Geographic Scales	If the ISMP is implemented at the appropriate scale and considers multi-scale effects (Doswald & Osti, 2011).
<i>Process</i>		
Maximum Stakeholder Involvement	Stakeholder Engagement	If the ISMP's design process engaged a broad range stakeholders from the outset to deliver an equitable, transparent and endorsed approach. Inclusive engagement strategy includes:

		<ul style="list-style-type: none"> <li>• Other levels of government</li> <li>• Private businesses</li> <li>• Research community</li> <li>• NGOs</li> <li>• Community Groups</li> <li>• Residents (Travers et al., 2012)</li> </ul>
	Involving Local Communities	If the design and implementation process encouraged residents to participate in both planning and implementation (Colls et al., 2009).
	Collaboration And Trust	If the ISMP was created through intergovernmental coordination and stakeholders. In addition, if the different groups developed trust to aid in successful implementation.
	Commitment Of Financial Resource	If the ISMP process is supported financially by Council.
Variety	Explore A Wide Variety Of Rainwater Management Options	If the ISMP explored multiple infrastructure options to achieve sustainable rainwater management.
	Work With Uncertainties	If the ISMP include infrastructure options that are effective in a variety of circumstances.
	Understanding Trade-Offs	If the ISMP includes a trade-off analysis of long vs. short term benefits of options, and/or ecosystem services.
Communication	Public Education And Awareness	If the ISMP includes at least 1 policy for public communication, behaviour change, education or participation on rainwater management issues (Baynham and Stephens, 2014).
<i>Implementation</i>		
Integrating Development	Cost Effectiveness	If general cost estimates for implementing the ISMP are identified and/or some financial or budget commitment is made.
	Providing Social, Economic And Environmental Benefit	If the ISMP's design strategies encompass multiple social, economic, and environmental benefits, such as reduced infrastructure costs, disaster risk reduction (flooding, urban heat island), carbon sequestration, sustainable rainwater management, and public education opportunities (Colls et al. 2009).
Governance	Accountable And Transparent Decision Making	If the ISMP's is designed and implemented with no negative impact on vulnerable populations or sensitive ecosystems (Andrade et al., 2011).
	Roles and Responsibilities	If ISMPs identify the departments, individual or other parties responsible for implementation assigned (Baynham and Stephens, 2014).

<i>Monitoring</i>		
Adaptive Management Approaches	Monitoring Timeline	If the ISMP indicates a timeline for monitoring to occur (Colls et al., 2009).
	Monitoring Actions	If the ISMP indicates action to undertake for comprehensive monitoring (Colls et al., 2009).
	Manage Climate Variability	If the ISMPs are designed to be flexible to allow the infrastructure to accommodate climate variations over time.
Resilience Building	Resilience vs. resistance	If the ISMP embraces change by encompassing flexible design practices to produce resilience rather than a path dependence resulting in local vulnerability to flood events (Mccarthy, 2012, pp. 31).
	Manage long-term climate change	If the ISMP encompasses a dynamic planning process that provides opportunities to adjust and improve infrastructure over time.
	Promote disaster risk reduction	If the ISMP uses natural system solutions to reduce vulnerability to flooding and extreme heat (Travers et al., 2012).
	Reducing non-climate stresses	If the ISMP minimizes other anthropogenic stresses that have degraded the condition of critical ecosystems, and thereby undermine their resilience to climate change. Such stresses include, <i>inter alia</i> , unsustainable harvests, habitat fragmentation, non- native species, and pollution (Colls et al., 2009).
Maintaining Ecosystems	Promote resilient ecosystems	If the ISMP promotes resilient ecosystems and use nature-based solutions to provide benefits to people. This involves: understanding what makes resilient ecosystems – and the services they provide and ensuring that local stewardship enhances both livelihoods and ecosystem management (Andrade et al., 2011).
	Maintain ecosystem services	If the ISMP includes a valuation of ecosystem services, identifies the options for managing ecosystems or managing human use, and involves user communities in management actions (Travers et al., 2012).
	Enhancing biodiversity	If the ISMPs considers the landscape prior to European settlement and seeks to mimic the original landscape and aims to provide additional or enhanced wildlife habitat for indigenous species.
	Resource Conservation	If the ISMP includes homeowner rainwater conservation practices.
	Avoid Mal-Adaptation	If the ISMP considers the negative impacts of engineered solutions on the natural system by analyzing the impacts of ISMP activities, aim to reduce negative impacts on the natural environment, and avoid inadvertent impacts on natural ecosystems and communities (Travers et al., 2012).

## 4.4. Analysis

Data analysis began during the literature review as reading, organizing, and coding data are a form of early data analysis (Galletta & Cross, 2013). I coded my literature using NVivo and used the memo feature in NVivo to track my analysis process to increase the rigor and transparency of my research. Coding of the literature for key concepts and variables is central to the final analysis because it identifies where the source of indicators used in the evaluation and how it relates to other indicators and principals in other ISMPs (Galletta & Cross, 2013).

To complete the analysis, both ISMP and non-ISMP documents were evaluated and given a score based on if the indicators were not mentioned, generally mentioned, or explicitly mentioned. The scores were given as follows:

- 0= Not Mentioned
- 1= Generally Mentioned
- 2= Explicitly Mentioned

The analysis score was applied by carefully reviewing each coded section for each indicator in each document. NVivo software allowed for a thorough analysis because every coded section is then saved under a specific indicator. The software allows the researcher to review each coded section and attribute an appropriate score. The score attributed to each coded section was based on whether the indicator was generally mentioned, explicitly mentioned, or not mentioned at all. The result of the number of times a particular indicator was coded for in each document is Appendix A.

### ***Evaluated ISMPs:***

Four ISMPs were evaluated for this research. According to the Upper Serpentine ISMP,

An ISMP is a comprehensive plan that examines the interrelationships between drainage servicing, land use planning, and environmental protection. Its purpose is to outline an approach to support and promote the growth of a community in a way that maintains, or ideally enhances, the health of a watershed. By applying an integrated approach, an ISMP can be used to link watershed and stream health to land use and policy decisions. Further, as a policy level document, an ISMP can be a powerful tool that can help a community achieve its vision. (Urban Systems, 2015, pp. 2).

All ISMPs follow the same principles as outlines in the Guidebook:

- Agree stormwater is a resource;
- Design for the complete spectrum of rainfall events;
- Act on a priority basis in at-risk drainage catchments;
- Plan for four scales – regional, watershed, neighbourhood and site; and
- Test solutions and reduce costs by adaptive management (Stephens et al., 2002, pp. ES-3)

### **City of Coquitlam’s Evaluated IWMPs:**

1. *Partington Creek IWMP*. Published in July 2011, 162 pages in length, not including appendices. The IWMP provides a summary of current watershed health; drainage inventory; environmental inventory; hydrogeological inventory, summary of current and proposed land uses; potential flood routing; key watershed issues; as well as recommendations for flood reductions, creek fan hazards, environmental protection, water quality, flow rate control, watercourse preservation, riparian setback protection, restoration and fish habitat protection, cost estimates and funding, and an implementation strategy.
2. *Nelson Creek IWMP*. Published June 2012, 170 pages, not including the 258 pages of appendices. The IWMP provides a summary of current watershed health; short, medium, and long term objectives; as well as recommendations for sediment erosion, stormwater and rainwater management, water quality, conveyance capacity, riparian enhancement strategy, fish habitat enhancement strategy, ditch management compensation strategy, and public education.

### **City of Surrey’s Evaluated ISMPs:**

3. *Ocean Bluff Chantrell Creek ISMP*. Submitted for review in June 2014, 98 pages, not including 33 pages of appendices. The ISMP includes a watershed assessment (inventory of drainage systems, existing geomorphological systems, water quality, vegetation and terrestrial habitat, benthic invertebrate bioassessment, stormwater and drainage criteria, hydraulic performance, climate change issues), vision – including a climate change adaptation, model management, monitoring, and adaptive management strategies.

4. Upper Serpentine ISMP. Draft submitted for review April 2015, totalling 272 pages. The ISMP includes an inventory of current watershed health; a vision for a healthy watershed; what is needed to achieve a healthy watershed; and future monitoring needed to maintain a healthy watershed.

***The non-ISMP documents evaluated include:***

- *City of Surrey: Biodiversity Conservation Strategy (BCS) (2014),*
- *City of Surrey: Climate Adaptation Strategy (Surrey's Adaptation Strategy) (2013)*
- *10-year Servicing Plan (2013),*
- *Metro Vancouver's Integrated Stormwater Management Plans Lessons Learned 2011 (2012),*
- *Metro Vancouver's A Watershed/Landscape-Based Approach to Community Planning (2002),*
- *Metro Vancouver's Integrated Liquid Waste and Resource Management: A Liquid Waste Management Plan for Greater Vancouver Sewerage & Drainage District and Member Municipalities (2010),*
- *A Guidebook for British Columbia: Stormwater Planning (2002), and*
- *Integrated Rainwater Management Planning: Summary Report for ISMP Course Correction Series (2011).*

As the goal of the research analysis is to elicit a yes/no binary response to the research question: Are ISMPs implementing EbA principles in Metro Vancouver? The measurement score of 0, 1, and 2 was used to easily identify how well the different EbA principles were represented in each ISMP and non-ISMP document evaluated. The measurement score was assigned based on an initial evaluation of each document using the evaluative framework. To complete the initial evaluation, all documents were uploaded into NVivo and coded for the indicators described in the evaluative framework. Once all documents were coded, I produced a coding matrix in NVivo, which generated a table with the number of times each indicator was coded, as well as identified the exact location within the document's text. The coded matrix tables generated by NVivo for ISMP and non-ISMP documents are presented in Appendix A.

Using the results in the coding matrix, I was able to find the source of each code within each document and evaluate whether the criteria for the indicator was generally or explicitly mentioned. If an indicator was not coded for, it received a score of zero. The measurement

score was synthesized based on City and not specific to each ISMP, the City of Coquitlam or the City of Surrey may have received a full score on any particular indicator even if only one their ISMPs met the requirement of the evaluation. The results of the evaluation are synthesized in Section 6: Findings.

### ***Limitations***

The initial limitation of this research project was the lack of successfully implemented ISMPs in Metro Vancouver. When the project started, approximately “25 ISMPs ha[d] been completed or [were] underway in Metro Vancouver – representing about half of the watersheds in the region” (Hicks & Howe, 2014). Many municipalities across the region are still in the writing and development phase of the ISMP process and have yet to successfully implement their ISMPs. The case study research method helped to overcome this limitation by allowing for the in depth evaluation of two ISMPs from two different municipalities with successfully implemented ISMPs. The two ISMPs evaluated from Coquitlam had been implemented; whereas the two from Surrey are in their final development stages and are slated to be implemented in the near future. The reason that yet to be implemented ISMPs were evaluated from Surrey, as opposed to existing implemented ISMPs, was due to the fact that the most recently developed ISMPs accounted for climate change projection scenarios, and previously written ISMPs did not.

The other limitation of this research project is limited discussion on what climate change impacts related to precipitation patterns are mitigated through ISMPs, and what impacts require further intervention. This information is beyond the scope of the research project and would require site-specific data collection to fully understand the scope of the ISMP’s ability to address all climate impacts. It was noted by research participants that ISMPs are ideal to address the rate of runoff for typical rain events; however, if climate impacts progress as projected, implemented ISMPs may not provide adequate storage capabilities for the increases in volume and frequency of rain events. In other words, additional interventions may be required to adequately adapt to changes in precipitation.

Similarly, this research only pertains to ISMPs and their inclusion of EbA principles. There are many climate change impacts that are going to affect Canadian municipalities and they cannot all be mitigated through ISMPs. As a result, this research is limited in its evaluation of ISMPs as an appropriate tool to implement EbA in urban areas. In addition, ISMPs are only

directly applicable to changes in precipitation and indirectly applicable to addressing the urban heating island effect and avoiding mal-adaptation. It would be interesting to know how EbA could be implemented in urban areas through other planning tools and how it can be used to mitigate more impacts of climate change, such as sea level rise and storm surge.

### ***EbA Limitations:***

Although there is tremendous evidence about the potential of EbA, limitations remain for its ability to fulfill all adaptation needs. The limitations exist due to the continued uncertainties around future climate conditions. Climate change projections are presented in a range of scenarios. Meeting future needs through adaptation actions is like hitting a moving target for adaptation planners. Similarly, the complex interactions of ecosystems required for optimal ecosystem service delivery is difficult to quantify. When the impact of climate change on ecosystems is considered in tandem with resulting impact to ecosystem services, significant uncertainty around the delivery of ecosystem services under various climate change conditions remains (Jones et al, 2012). In other words, adaptation planners need to figure out the adaptive abilities of ecosystems under future climate change scenarios. In addition, global practices of consumption, i.e. forestry, fishing, mining, transportation, and development are all putting stress on ecosystems that may provide adaptation services; therefore, knowing which services are threatened by specific actions is also important for adaptation planners (Jones et al, 2012).

More specifically to limits of implementing EbA through ISMPs, key stakeholder identified the limits of ISMPs to inherently address future climate change vulnerabilities relating to rainwater. For example, ISMPs currently work really well to address frequent low volume rain events; however, as the volume and frequency of rain events increase, current rainwater management strategies as prescribed through ISMPs may not provide adequate adaptation to high volume rain events. This means that other adaptation measures will be required to meet all needs. As ISMPs are implemented and go through the required adaptive management review, new required measures may be identified that meet the needs of the specific watershed. Alternatively, the ISMP guidebook may also be revised to incorporate suggested outcomes such as wetland type storage or blue infrastructure features that double as water storage facilities for large rain events.

## **Chapter 5.**

### **CASE STUDIES**

The case studies evaluated in this project were decided through the initial interview process and literature review. Metro Vancouver was selected as the region for the study because ISMPs are legislated for all member municipalities. The City of Surrey and the City of Coquitlam were selected as case cities during the initial expert interview process. They were selected because both have complete and successfully implemented ISMPs, are recognized as regional champions of the ISMP process, and were willing to participate in the study.

Upon initial interviews with research participants from the City of Surrey and City of Coquitlam, the following case study sites were selected. The research participant from the City of Coquitlam recommended evaluating Nelson Creek and Partington Creek as both IWMPs were written for contrasting land use and geomorphic characteristics. The research participant from the City of Surrey suggested evaluating Upper Serpentine and Ocean Bluff/ Chantrell Creek ISMP because they are active ISMPs near completion. Furthermore, they reflect the City's most up to date work on ISMPs, include improvements from previous experiences, incorporate climate change projections, and seek adaptation measures through the ISMPs.

#### **5.1. City of Surrey**

The City of Surrey is comprised of six communities: Cloverdale, Fleetwood, Guildford, Newtown, South Surrey, and North Surrey. In 2014, 508,040 people lived in the City of Surrey and the City projects the population to increase to 812,200 by 2046 (City of Surrey, 2015a). Future population projections are an important consideration for planners and engineers when planning for future land uses and accommodating stormwater management systems. Surrey's land uses include conservation and recreation; agricultural; rural; suburban; suburban-Urban reserve; urban; multiple residential; commercial; industrial; mixed employment; town centre; central business; and First Nations Reserve (City of Surrey, 2013b).

The City of Surrey monitors and evaluates its urban watersheds through Drainage Study Areas (City of Surrey, 2015b). The drainage reports contain relevant information on the existing drainage systems throughout Surrey. Surrey collects information on the following:

- Overall catchment area
- Drainage sub catchment areas
- Catchment characteristics (such as land use, rainfall patterns, groundwater, soils, slopes, slope stability)
- Contaminated sites
- Environmentally sensitive areas
- Terrestrial Wildlife issues
- Watercourses
- Water quality issues
- Erosion concerns
- Minor flows (5 year design storm runoff)
- Major flows (100 year design storm runoff)
- Existing storm system infrastructure and capacity
- Proposed storm system infrastructure and capacity (City of Surrey, 2015b).

The information contained in the Drainage Study Area Reports is integral for and found in the City's various ISMPs.

Surrey refers to ISMPs as “a comprehensive, ecosystem-based approach to rainwater management” and is committed to having ISMPs for every watershed in the City. To date, Surrey has completed nine ISMPs and has eight active ISMPs set to be complete in the next year (City of Surrey, 2015c). Many of Surrey's planning documents reference the ISMPs, such as the Sustainability Strategy, Adaptation Strategy, Biodiversity Strategy, 10-year Servicing Plan, Roads and Infrastructure, Green Infrastructure Network (GIN), and Ecosystems study.

Two active ISMPs near completion were evaluated for this project:

### ***Ocean Bluff/ Chantrell Creek ISMP***

Ocean Bluff/ Chantrell Creek watersheds are located in southwest Surrey and are approximately 1,800 hectares in size (City of Surrey, 2015c). The City of Surrey initiated the Ocean Bluff/ Chantrell Creek ISMP in 2012 (City of Surrey, 2015c). The area consists of both urban and suburban areas, with no substantial development or re-development anticipated (City of Surrey, 2015c). Fish passage, habitat and erosion are areas of concern for Ocean Bluff/ Chantrell Creek.

## ***Upper Serpentine ISMP***

The Upper Serpentine ISMP watershed is “between 144th Street and 188th Street, and 82nd Avenue to 112th Avenue” and covers approximately 2,616 hectares (City of Surrey, 2015c). Both Guildford Town Centre and Tynehead Park are located within the watershed, making the residents and land uses very diverse. Land uses within the watershed include single family and multi-family residential, commercial, institutional, parks, and light industrial (City of Surrey, 2015c). The northern sections of the watershed have more natural features around the rivers and the lower parts of the watershed are contained by a dike system (City of Surrey, 2015). There are seven tributaries to the Upper Serpentine River within the study area: Hjorth Creek, Acason Creek, Bothwell Creek, E Creek, Austin Brook, Swanson Brook, Lakiotis Creek (City of Surrey, 2015c).

## **5.2. City of Coquitlam**

The City of Coquitlam is located east of the City of Vancouver and has a population of approximately 141,132 (City of Coquitlam, 2015a). Coquitlam is comprised of four areas: Southwest Coquitlam, Northwest Coquitlam, Northeast Coquitlam, and the City Centre. Coquitlam’s land use designations include: agricultural, civic and major institutional, compact one family residential, extensive recreation, general commercial, high density apartment, business enterprise, industrial, low density apartment, medium density apartment, mobile home park, natural areas, neighbourhood attached residential, neighbourhood centre, one family residential, parks and recreation, school, service commercial, service commercial, town housing, transit village commercial, urban quarter, urban town housing, and waterfront village centre (City of Coquitlam, 2002).

Coquitlam’s City Wide Official Community Plan (CWOCP) recognizes the need to balance the needs of current and future infrastructure needs. Stormwater management is listed as an area where the City is taking new approaches and implementing new practices; however, effectiveness and cost efficiency remains to be determined (City of Coquitlam, 2002). In response to these concerns, the CWOCP suggests the following policies:

- a) Continue to implement proven approaches, practices, and standards to the provision of infrastructure services.
- b) Monitor and assess new approaches and standards for the provision of infrastructure services.
- c) Initiate pilot projects to assess the viability of new approaches in partnership

with key stakeholders such as the GVRD, landowners, community groups, and federal and provincial agencies in stormwater management. (City of Coquitlam, 2002, 7-14)

The City of Coquitlam continues to implement policies outlined in the CWOCP and is developing IWMPs for all urban watersheds with the aim “to preserve watershed health, while also meeting community needs and facilitating growth and development” (City of Coquitlam, 2015b). IWMPs employ a net environmental approach that strives to enhance fish and fish habitat (City of Coquitlam, 2015 b). The two IWMPs from Coquitlam evaluated in this study are the Partington Creek IWMP and the Nelson Creek IWMP.

### ***Partington Creek IWMP***

Partington Creek is located on Burke Mountain in northeast Coquitlam. The 625 ha watershed is “mainly covered by second growth forest, and supports rich aquatic and wildlife systems” (City of Coquitlam, 2015b). The Northeast Coquitlam Area Plan is a Greenfield development plan and has a capacity of 7,500 dwelling units and 24,000 people (City of Coquitlam, 2015, b). The Partington Creek IWMP is assisting in the development planning process to ensure new development is not harmful to the watershed.

The City of Coquitlam addresses the following key issues through the Partington Creek IWMP:

- Flooding in low lying farmlands
- Stream flow protection
- Stream water quality protection
- Riparian area protection
- Fish habitat restoration and enhancement
- Mitigation of stream erosion and sediment management
- On-site Rainwater Management to mimic the natural hydrology
- Integration of Land development with stormwater management (City of Coquitlam, 2015b).

### ***Nelson Creek IWMP***

The Nelson Creek watershed is approximately 250 ha in area and is located in southwest Coquitlam (City of Coquitlam, 2015b). The upper parts of Nelson creek are contained within the underground pipe system but opens in downstream areas.

The City of Coquitlam addresses the following key issues in the Nelson Creek IWMP:

- Integrate land development with stormwater management
- Stream water quality

- On-site Rainwater Management to mimic natural hydrology
- Stream erosion and sediment transport
- Stormwater detention and diversion
- Storm system capacity
- Aquatic habitat restoration and enhancement
- Riparian area protection (City of Coquitlam, 2015b).

## Chapter 6.

### FINDINGS

The findings of the research are presented in two sections. The first section presents the results of the evaluation of ISMP documents from the City of Coquitlam and the City of Surrey. These results include the direct evaluation of the Partington Creek IWMP, Nelson Creek IWMP, Ocean Bluff/ Chantrell Creek ISMP, and Upper Serpentine ISMP. The second section presents the results from the evaluation of non-ISMP documents. The non-ISMP documents were categorized as municipal, regional, or provincial in context. These documents consist of policy and planning documents at the municipal and regional level. The provincial level documents are ISMP guiding documents.

#### 6.1. ISMPs Evaluation Results

**Table 2: ISMP Evaluation Result Summary**

Principles	Indicators	Coquitlam	Surrey
<i>Fact Base</i>			
Knowledge Based Adaptation	Climate Change As An Issue	0	2
	Impacts Of Climate Change	0	2
	Vulnerability Assessment	0	1
	Best Available Science	2	2
	Local Climate Change Projections	0	2
Goals			
Address Climate Change	Adaptation	1	2
Multi-scale Operations	Integration With Development	2	2

	Strategies		
	Sectoral Adaption Planning	2	2
	Multiple Geographic Scales	1	2
Process			
Maximum Stakeholder Involvement	Stakeholder Engagement	2	2
	Involving Local Communities	2	2
	Collaboration And Trust	2	2
	Commitment Of Financial Resource	2	2
Variety	Explore A Wide Variety Of Rainwater Management Options	2	2
	Work With Uncertainties	1	2
	Understanding Trade-Offs	2	2
Communication	Public Education And Awareness	2	2
Implementation			
Integrating Development	Cost Effectiveness	2	2
	Providing Social, Economic And Environmental Benefit	2	2
Governance	Accountable And Transparent Decision Making	0	0
	Roles and Responsibilities	1	1
Monitoring			
Adaptive Management Approaches	Monitoring Timeline	2	1
	Monitoring Actions	2	2
	Manage Climate Variability	1	1
Resilience Building	Resilience vs. resistance	1	2
	Manage long-term climate change	1	1

	Promote disaster risk reduction	2	2
	Reducing non-climate stresses	2	2
Maintaining Ecosystems	Promote resilient ecosystems	2	1
	Maintain ecosystem services	2	2
	Enhancing biodiversity	2	2
	Resource Conservation	2	1
	Avoid Mal-Adaptation	2	2
	<b>Total/68</b>	<b>49</b>	<b>57</b>

The ISMPs reviewed include:

- City of Coquitlam's *Partington Creek IWMP* and *Nelson Creek IWMP*
- City of Surrey's *Ocean Bluff Chantrell Creek ISMP* and *Upper Serpentine ISMP*.

### 6.1.1. ISMP Results Explored in Detail

The following section explores the results of the evaluation of ISMP documents in closer detail. The result sections are separated into the principles of EbA and the score given for each indicator is justified through evidence from the text of the specific ISMP from the City of Coquitlam or City of Surrey. The aim is to identify if the ISMPs explicitly, generally or do not include EbA principles.

#### **Fact Base**

#### **Principle: Knowledge Based Adaptation**

**Table 3: ISMP Detailed Evaluation Results for Knowledge Based Adaptation**

Indicator	Coquitlam	Surrey
Climate Change As An Issue	0	2

Impacts Of Climate Change	0	2
Vulnerability Assessment	0	1
Best Available Science	2	2
Local Climate Change Projections	0	2

The 'Climate Change as an Issue' indicator identifies if climate change is framed as an issue facing the local or global community (Baynham & Stephens, 2014). Both Ocean Bluff/ Chantrell Creek ISMP and Upper Serpentine ISMP explicitly identify climate change as an issue that needs to be considered in future servicing scenarios. The City of Surrey recognizes that rain patterns will change over time, specifically the intensity and frequency of heavy rain events, and include two scenarios for consideration. Upper Serpentine ISMP states “[i]n the absence of definitive understanding or agreement of future rain patterns and events, two “climate change” scenarios were tested for the unmanaged future conditions by increasing the rainfall depths in the City’s current design storms by 10% then by 20%. The ISMP uses these two scenarios to run models for future projections for future 2 year frequent storm events” (pp. 53).

The 'Impacts of Climate Change' indicator finds if the ISMP identifies the expected impacts specific to the municipality (Baynham and Stephens, 2014). Both Ocean Bluff/ Chantrell Creek ISMP and Upper Serpentine ISMP explicitly discuss the expected impacts of climate change specific to Surrey. For example, the Upper Serpentine ISMP states:

it is seen that rainfall increases of this magnitude would put increasing pressure on the storm trunk system, to the point that about 2/3 of all pipes in Zone 1A could potentially surcharge (pipes shaded with yellow or orange) and flooding at manholes (larger circles at the nodes) becomes a common occurrence. Some of this additional surcharging and flooding would be mitigated by the presence of the existing detention ponds, but not all of it. As will be discussed in the next section, application of green infrastructure can take up some slack but not all if rainfall intensities experience increases of the magnitude assessed here (Urban Systems Ltd., 2015, pp. 53).

The Ocean Bluff/ Chantrell Creek ISMP summarizes the impacts of the climate change in the watershed as “[a]lthough most of the Ocean Bluff and Chantrell Creek drainage areas are in high elevation, there are some low-lying areas, vulnerable to the effects of climate change, such as sea level rise, storm surge, and rainfall increases” (pp. 46). The ISMP also directly references the impacts and projections identified in Surrey’s Adaptation Strategy.

The 'Vulnerability Assessment' indicator is evidence of the ISMP identifying impacts of climate change as a rationale for implementing the ISMP (Baynham & Stephens, 2014). This indicator is problematic because all Metro Vancouver municipalities are required to develop ISMPs and therefore municipalities do not need additional rationale for implementing ISMPs. With that said, the City of Surrey still fulfilled this indicator as they had Urban Systems prepare a report titled "Crescent Beach Climate Change Adaptation Study" in 2009. The report conducted a thorough assessment of the drainage system under existing and future climate change conditions and the results of the assessment influenced recommendations in the ISMP.

The 'Best Available Science' indicator considers if the ISMP identifies scientific evidence for land use, soil and drainage, ecology, flood management, water quality, wildlife habitat, watershed mapping, and sensitive ecosystem identification. The City of Coquitlam identifies the Total Impervious Area (TIA) and Riparian Forest Integrity, as well as the issues in the Nelson Creek watershed. Issues include:

- Stream channel erosion and sediment transport
- Poor water quality (i.e., for elevated fecal coliforms, nutrients, some metals)
- Limited conveyance capacity
- Alteration of fish and riparian habitat (CH2M Hill, 2012, pp. 3)

Coquitlam also identifies fish species in Nelson Creek, such as coastal cutthroat trout, which is a blue-listed species in BC. The IWMP explains in detail the methods for which they collect fish presence data. Water quality samples at each site measure metals, nutrients, coliforms, temperature, conductivity, turbidity, pH, and dissolved oxygen.

For Partington Creek, the City of Coquitlam measures benthic invertebrates to assess the biological condition and health of the creek, as well as provide a baseline condition that can be used to "monitor the effectiveness of stormwater management" actions (HB Lanarc & Raincoast, Kerr Wood Leidal, 2011 pp. 3-5). Land use and land cover are also identified in the Partington Creek IWMP, particularly that second growth forests cover 90% of the watershed. The TIA is calculated at 1.3% and only 5.8% if the area is developed (roads, buildings, grass, landscaped areas). Water flow, peak flows, snowmelt assumptions, base flows, and rainfall is also monitored and collected by Coquitlam.

The City of Surrey, via Dillon Consulting Limited, completed a field assessment and literature review to assess:

- Watercourse habitat value and classification;
- Fish presence potential and barriers to access;
- Riparian extent and condition;
- Benthic invertebrate composition;
- Wildlife corridors, hubs, and patches along with an inventory of possible species;
- Terrestrial habitat values of treed and wooded areas;
- Potential presence of rare species and ecosystems;
- Invasive species presence;
- Sensitive environmental areas;
- Biodiversity; and
- Potential water quality issues (Urban Systems Ltd., 2015 pp. 135).

The City of Surrey has also conducted a science-based Ecosystem Management Study (EMS) to identify and map its GIN. The EMS identifies ecological hubs hosting complex ecological processes, ecological sites of importance, and ecological/ wildlife corridors. Within the Chantrell Creek watershed, site visits were conducted to verify vegetation communities, wildlife habitat and corridors, and different species of wildlife and vegetation that inhabit the watershed (Tetra Tech EBA, 2014).

## **Goals**

### ***Principle: Address Climate Change***

**Table 4: ISMP Detailed Evaluation Result for Address Climate Change**

<b>Indicator</b>	<b>Coquitlam</b>	<b>Surrey</b>
Adaptation	1	2

The 'Adaptation Indicator' is looking for if the ISMP has broad or general goals related to adaptation or reducing vulnerability to climate change (Baynham and Stephens, 2014). Goal #5 of the Upper Serpentine ISMP is "Consider Climate Change Implications" and states: "changes in rainfall pattern distributions and amounts will likely have an impact on how future drainage infrastructure is designed. ISMP drainage infrastructure recommendations should align with an adaptive management mindset and strive to incorporate design resiliency to account for future climate change predictions" (pp. 31). The Upper Serpentine ISMP will incorporate adaptation measures in the form of "performance targets for onsite stormwater management source

controls to address peak flow attenuation, volume reduction and water quality treatment.” The Ocean Bluff/ Chantrell Creek ISMP referenced the vision outlined in Surrey’s Adaptation Strategy (City of Surrey, 2013a): “the City of Surrey will be resilient in the face of a changing climate”, and will also: “...take timely action to reduce the risks of climate change and thereby minimize social, environmental, and economic costs in the future” (pp. 16).

Neither Nelson Creek IWMP nor Partington Creek IWMP explicitly mention adaptation or reducing vulnerability to climate change as a goal, but they both mention reducing or designing for peak flows under existing and future conditions. In this instance, future conditions may only be referring to changes in land use, but as ISMPs are updated through adaptive management principles, climate change projections may be incorporated in the future as models for peak flows are adjusted. Another adaptation measure discussed in the Partington Creek IWMP is that “[n]ative vegetation should be left intact where possible, or restored to preserve and enhance evapotranspiration” (HB Lanarc & Raincoast, Kerr Wood Leidal, pp. 3-9). Enhancing evapotranspiration will help alleviate some impacts of UHI as the moisture released through evapotranspiration cools the surrounding area (see environmental and social benefits section).

***Principle: Multi-scale Operations***

**Table 5: ISMP Detailed Evaluation Result for Multi-scale Operations**

Indicator	Coquitlam	Surrey
Integration with Development Strategies	2	2
Sectoral Adaptation Planning	2	2
Multiple Geographic Scales	1	2

The ‘Integration with Development Strategies’ indicator detects if the ISMP identifies or is incorporated into a broader planning strategy in the region. Surrey’s Upper Serpentine ISMP identifies the planning policy documents that integrate ISMPs within broader development strategies. The documents listed in the Upper Serpentine ISMP include:

- Surrey’s Sustainability Charter,
- Official Community Plan,
- Climate Adaptation Strategy,
- Zoning Bylaws,
- Stormwater Drainage Regulation and Bylaw,

- Drainage Parcel Tax Bylaw,
- Subdivision and Development Bylaw,
- Soil Conservation and Protection Bylaw,
- Tree Cutting and Tree Preservation Bylaws,
- Floodplain Development Policy,
- Ecosystem Management Study, and the
- Biodiversity Conservation Strategy.

The Upper Serpentine ISMP also identifies the 10-year Capital Plan as an opportunity to implement ISMPs through road improvements throughout the watershed. The plan also notes the potential planning processes, such as the Guildford Town Centre and Fleetwood Town Centre planning processes, opportunities to implement performance targets, features and facilities. Last, goal # 11 of the plan states: “Align ISMP with Land Use Planning Initiatives in the Watershed. Completing the ISMP in advance of the Guildford Town Centre and Fleetwood Town Centre Plans offers a unique opportunity to infuse integrated stormwater management approaches directly into the planning process” (pp. 40). The Ocean Bluff/Chantrell Creek ISMP has similar provisions throughout to align the ISMP with development strategies.

The Nelson Creek IWMP explicitly states, “integrate the IWMP with the land-use planning processes” as a means to achieve the long-term watershed vision (pp. 1-3). The Partington Creek IWMP complements “the City’s OCP and overall development strategy” (pp. 1-2). In addition, the IWMP provides input for the neighbourhood plan to align development strategies with watershed goals.

The ‘Sectoral Adaptation Planning’ indicator identifies if the ISMP utilized the expertise of planner, engineers, and scientific experts, such as ecologists for its development (Colls et al., 2009). At the City of Coquitlam, “a multi-disciplinary consulting team of engineers, planners, and biologists, together with City Staff from multiple departments, DFO, and an Advisory Committee worked together to develop a plan that strived to meet the interests of many” (HB Lanarc & Raincoast, Kerr Wood Leidal, pp. 1-2). Coquitlam used similar groups of people to develop both of the IWMPs evaluated in this project. Similarly, at the City of Surrey,

[t]he ISMP Team for the Upper Serpentine Watershed [was] made up of a diverse group of City staff from various departments including: Engineering; Environment; Planning and Development; Parks, Culture and Recreation; Technology and Finance; Transportation; Building; and the Sustainability Office. City Staff were supported by an external consulting team consisting of Urban Systems (engineering, planning and landscape architecture), Dillon Consulting (environmental) and Thurber Engineering (geotechnical) on this project (pp. 6).

The ‘Multiple Geographic Scale’ indicator examines if the ISMP is implemented at the appropriate scale and considers multi-scale effects (Doswald & Osti, 2011). ISMP’s by their nature are implemented at the appropriate scale as they are developed at the watershed scale regardless of jurisdictions, so this indicator is met at a basic level. The City of Surrey explicitly mentions the multiple scale effects of their ISMPs, such as the benefits of public stormwater retention facilities versus smaller, localized, private retention facilities (Urban Systems Ltd., 2015). The City of Coquitlam IWMP’s were not coded for explicit mentions of various scale affects of their IWMPs; however, as mentioned above, they inherently fulfill this requirement.

**Process**

**Principle: Maximum Stakeholder Involvement**

**Table 6: ISMP Detailed Evaluation Result for Maximum Stakeholder Involvement**

Indicator	Coquitlam	Surrey
Stakeholder engagement	2	2
Involving local communities	2	2
Collaboration and Trust	2	2
Commitment of Financial Resources	2	2

The ‘stakeholder engagement’ indicator investigates if the ISMP design process engaged broad range stakeholders from the outset to deliver an equitable, transparent and endorsed approach. Inclusive engagement strategy includes other levels of government, private businesses, research community, NGOs, community Groups, and residents (Travers et al., 2012). The City of Surrey developed a specific engagement strategy for the Upper Serpentine ISMP. The ISMP states:

[t]he [engagement] strategy was developed to create awareness around the project and provide opportunities for external stakeholders to contribute to the project. Internally, the strategy provides the resources and opportunities necessary for City staff on the ISMP project team to work collaboratively towards an implementable ISMP for the Upper Serpentine Watershed. Both internal and external stakeholders have been identified within the strategy. Externally, stakeholders include those who live, work, and recreate within the Study Area. Internally, stakeholders include City staff from various departments that make up the City’s ISMP Team (pp. 5).

The City of Coquitlam’s Nelson Creek IWMP generally mentions that City Staff and interest groups were consulted for the plan; whereas, Partington Creek IWMP explicitly

mentions the members of the steering committee, the advisory committee, the engagement activities, as well as stakeholders input and guidance for the final IWMP.

The ‘Involving Local Communities’ indicator examines if the design and implementation process encouraged residents to participate in both planning and implementation (Colls et al., 2009). Upper Serpentine ISMP explicitly mentions that “[t]he ISMP will recommend interim measures that could be applied by the City, residents, businesses, partners and external stakeholders to begin to improve watershed conditions in the short term. Interim measures may include educational, adaptive planning, or physically based approaches” (pp. 39). The City of Coquitlam’s Nelson Creek IWMP explicitly mentions the actions that will be recommended for local residents to take to assist in implementing the IWMP. For example, the IWMP states:

“Public Education and Stewardship:

- Harness the efforts of passionate community members in stewardship and education;
  - Work with property owners throughout the watershed to enhance watershed health through methods including:
    - Increase onsite infiltration on private and public property
    - Provide landscape treatment
    - Provide site design
    - Provide onsite spill control
  - Work with property owners in the lower section of the creek to protect and enhance the creek, particularly when a redevelopment proposal is submitted” (pp. 1-3).

The ‘Collaboration and Trust’ indicator inquires if the ISMP was created through intergovernmental coordination and stakeholders, as well as if the different groups developed trust to aid in successful implementation. City of Surrey’s ISMPs list the various stakeholders that were involved with developing the ISMPs, as well as, the common goals and vision for the implementation of the document. Similarly, the City of Coquitlam’s IWMPs list the stakeholders involved in producing the documents, as well as, list some of the stakeholders concerns and how they were addressed in the final plan. Addressing concerns illustrates collaboration and trust amongst the stakeholders.

The ‘Commitment of Financial Resources’ indicator is looking for evidence that Council supports the ISMP process financially. The City of Surrey funds their ISMPs primarily through Development Cost Charges and the Parcel Drainage Tax, which charges residents and businesses a flat fee based on their property type, and developer contributions. The City of Surrey is also keen to identify alternative funding mechanisms through leveraging resources from other areas that meet multiple objectives, such as green infrastructure and road improvements. Similarly for the City of Coquitlam, the Partington Creek IWMP explains that

funding for IWMPs is from Development Cost Contributions, Sewage and Drainage Tax, as well as external funding in the form of grants from senior levels of government, environmental groups, and in kind donations from volunteer groups.

***Principle: Variety***

**Table 7: ISMP Detailed Evaluation Result for Variety**

Indicator	Coquitlam	Surrey
Explore A Wide Variety Of Rainwater Management Options	2	2
Work With Uncertainties	1	2
Understanding Trade-Offs	2	2

The ‘Explore A Wide Variety Of Rainwater Management Options’ indicator identifies if the ISMP explored multiple infrastructure options to achieve sustainable rainwater management. Both of the City of Surrey’s ISMPs evaluated explore a wide variety if rainwater management options. The plans call for a combination of green and grey infrastructure solutions. Some of the proposed green infrastructure solutions include:

physical elements such as landscape-based retention / water quality treatment facilities, subsurface engineered facilities, porous pavement and green roofs, as well as planning based elements such as impervious area reduction, easing of on-lot parking requirements, encouraging cluster-style developments that retain high value natural areas, and encouraging vertical-oriented development over lower density or suburban development (Urban Systems Ltd., 2015, pp. 39).

Similarly, the City of Coquitlam’s IWMPs evaluate different rainwater management options, from community storage to diversion pipes. The options evaluated in the plan combine green and grey infrastructure solutions.

The indicator for “Work with Uncertainties” investigates if the ISMP includes infrastructure options that are effective in a variety of circumstances. Both of Surrey’s ISMPs evaluated discuss uncertainties within their models or baseline data. The documents also explain how they are working with these uncertainties and are exploring options to account for unknowns such as climate change impacts. The City of Coquitlam’s IWMP refer to uncertainties regarding peak flow rates and the appropriate infrastructure solutions.

The ‘understanding trade-offs’ indicator explores if the ISMP includes a trade-off analysis of long vs. short-term benefits of options, and/or ecosystem services. The City of Surrey’s Upper

Serpentine ISMP explicitly explores the long-term trade-offs between various rainwater management options. The City of Coquitlam’s IWMPs also explores the trade-offs between opportunities for environmental protection, especially regarding fish habitat, and future development considerations.

***Principle: Communication***

**Table 8: ISMP Detailed Evaluation Result for Communication**

Indicator	Coquitlam	Surrey
Public Education And Awareness	2	2

The indicator ‘Public Education and Awareness’ explores if the ISMP includes at least 1 policy for public communication, behaviour change, education or participation on rainwater management issues (Baynham and Stephens, 2014). Both of the City of Surrey’s ISMPs have a section that outlines the public outreach and education for the plan. Similarly, the City of Coquitlam’s Nelson Creek IWMP explicitly mentions public education strategies to enhance homeowner rainwater management abilities.

***Implementation***

***Principle: Integrating Development***

**Table 9: ISMP Detailed Evaluation Result for Integrating Development**

Indicator	Coquitlam	Surrey
Cost Effectiveness	2	2
Providing Social, Economic And Environmental Benefit	2	2

The ‘cost effectiveness’ indicator asks if general cost estimates for implementing the ISMP are identified and/or some financial or budget commitment is made. This indicator is very similar to ‘commitment of financial resources,’ with the significant difference being whether or not the local government had provided an estimate for how much implementing the ISMP would cost and if they had identified a funding source.

The City of Surrey's Upper Serpentine ISMP provides a detailed cost estimate in an appendix and a brief description in the document: "[depending on the extent of work to be completed, the costs for potential in-stream improvements varies from \$1.6 to \$3.1 million, with associated annual maintenance costs of \$30,000. See Appendix C for details" (pp. 73). Interestingly, it makes note of the fact that that servicing upgrades are not along a major road corridor and cannot therefore be "piggybacked as a cost reducing factor" (pp. 73).

Similarly, both of the City of Coquitlam's IWMPs aim to be as cost effective as possible, indicating that cost effective measures need to be taken into consideration and municipal budget constraints recognized. Partington Creek IWMP provides a cost estimate: "[t]he IWMP works such as diversion pipe, baseflow augmentation facilities, water quality ponds, sediment traps, and relocation and enhancement of Cedar Drive has an estimated cost of about \$31 million. The main components of the works will be constructed as City capital projects funded from DCCs" (HB Lanarc & Raincoast, Kerr Wood Leidal, 2011, pp. 1-4).

The 'Providing Social, Economic and Environmental Benefit' indicator was coded when the ISMP illustrated the ISMP's design strategies encompass multiple social, economic, and environmental benefits, such as reduced infrastructure costs, disaster risk reduction (flooding, urban heat island), carbon sequestration, sustainable rainwater management, and public education opportunities (Colls et al. 2009). Some of the potential environmental benefits outlined in the Upper Serpentine ISMP included wider stream setbacks to act as riparian wildlife corridors, removal of invasive species, improve fish access, replant native species, initiate a public awareness campaign about riparian and stream health, and find opportunities to enhance corridor access through partnerships with BC Hydro. The City of Surrey also aligns the goals of their evaluated ISMPs with other development strategies providing social, economic and environmental benefits, such as the GIN study, Sustainability Charter, Adaptation Strategy, and the BCS. Similarly, both the City of Coquitlam's IWMPs reference goals of balancing social, environmental and economic benefits. Nelson Creek IWMP elaborates on this and states: "[i]t strives to preserve watershed health as a whole, but also meet community needs and facilitate growth and development. The IWMP investigates issues related to the quality and quantity of rainwater runoff, flood protection, environmental protection of aquatic resources, wildlife and their habitats, land use, green ways, and recreation" (pp. 3).

**Principle: Governance**

**Table 10: ISMP Detailed Evaluation Result for Governance**

<b>Indicator</b>	<b>Coquitlam</b>	<b>Surrey</b>
Accountable And Transparent Decision Making	0	0
Roles and Responsibilities	1	1

The indicator ‘Accountable and Transparent Decision Making’ asks if the ISMPs is designed and implemented with no negative impact on vulnerable populations or sensitive ecosystems (Andrade et al., 2011). As this indicator is looking for the explicit mention of the decision making process, neither the City of Coquitlam nor City of Surrey ISMPs was coded for this indicator; however, as explored further in the discussion section, sensitive ecosystems are inherently taken into account through the ISMP process but decision making process is not included in the ISMP.

The indicator for ‘Roles and Responsibilities’ asks if ISMPs identify the departments, individual or other parties responsible for implementation (Baynham & Stephens, 2014). The City of Surrey recognizes the importance of delegating roles and responsibilities to ensure successful implementation of the ISMP, though the plan itself does not appear to list the break down of the roles and responsibilities. Personal communications with Surrey’s research participant clarified that the engineering department is responsible for implementation and they are responsible for making final decisions regarding implementation (July 6, 2015). Transparency in the decision making process is at the financial stages when ISMP work is approved by Surrey’s Council in the public budget approval process. The City of Coquitlam’s Nelson Creek IWMP generally mentions the need to have plans for implementation and maintenance.

**Monitoring**

**Principle: Adaptive Management Approaches**

**Table 11: ISMP Detailed Evaluation Result for Adaptive Management**

Indicator	Coquitlam	Surrey
Monitoring Timeline	2	1
Monitoring Actions	2	2
Manage Climate Variability	1	1

The principle of adaptive management approaches is especially interesting as it is a concept that is deeply embedded in both EbA and ISMPs (Stephens, Graham, & Reid, 2002; Huq, Renaud, & Sebesvari, 2013). The indicator for ‘Monitoring Timeline’ explores if the ISMP indicates a timeline for monitoring to occur (Colls et al., 2009). The City of Surrey’s ISMPs were not coded for this indicator explicitly but the plans make reference that monitoring actions will be conducted over time. Monitoring timelines are explained in Metro Vancouver’s “Draft Monitoring and Adaptive Management Framework.” Both of the City of Coquitlam’s IWMPs reference monitoring timelines for different monitoring actions. Some areas are monitoring bi-annually, yearly, or 2-5 year cycles.

The indicator for ‘Monitoring Actions’ investigates if the ISMP indicates actions to undertake for comprehensive monitoring (Colls et al., 2009). Both of City of Surrey’s ISMPs evaluated make reference to Metro Vancouver’s “Draft Monitoring and Adaptive Management Framework” and describe how the aspects of this framework are applied in their plan. Both of the City of Coquitlam’s IWMPs make reference to the monitoring actions that will be undertaken through the plan. For example, Partington Creek IWMP states:

On-going performance indicator monitoring is needed to assess the success of the IWMP implementation and allow for adaptive management to protect the watershed’s environmental values. The monitoring program includes stream flow monitoring, benthic invertebrate surveys, fish counts and water quality testing to quantify the ecological health of the watershed. Tracking total and effective impervious area, riparian forest integrity and channel erosion over time would also be useful performance indicators (HB Lanarc & Raincoast, Kerr Wood Leidal, 2011, pp. 1-4).

The indicator for ‘Manage Climate Variability’ indicates if the ISMPs are designed to be flexible to allow the infrastructure to accommodate climate variations over time. The City of Surrey’s Upper Serpentine ISMP identifies climate change as a consideration and that various future scenarios are taken into consideration for infrastructure design, including adopting an adaptive management mindset. The plan does not elaborate on if and how the plan is adaptable over time. Personal communications with Surrey’s research participant indicated the plan is revised every 12-14 years, as per the original Liquid Waste Management Plan requirements,

and it can be adapted during this planning cycle. City of Coquitlam’s Partington Creek IWMP includes this statement: “In addition to monitoring the implementation plan it is also necessary to have a method for correcting any shortcomings. The results of the monitoring program will be reviewed annually and modifications to City policies, the rainwater source controls, and other mitigation strategies will be made and implemented in the remaining development in the watershed” (HB Lanarc & Raincoast, Kerr Wood Leidal, 2011, pp. 10-2). While this does not directly refer to climate variations, reviewing monitoring results regularly will help provide insight into the changing climate and areas where the City can adapt to become more resilient over time.

***Principle: Resilience Building***

**Table 12: ISMP Detailed Evaluation Result for Resilience Building**

<b>Indicator</b>	<b>Coquitlam</b>	<b>Surrey</b>
Resilience vs. resistance	1	2
Manage long-term climate change	1	1
Promote disaster risk reduction	2	2
Reducing non-climate stresses	2	2

The indicator for ‘Resilience vs. Resistance’ investigates if the ISMP embraces change by encompassing flexible design practices to produce resilience rather than a path dependence resulting in local vulnerability to flood events (McCarthy, 2012, pp. 31). Both of Surrey’s ISMPs make reference to resilience measures within the watershed. For the Upper Serpentine ISMP, it is in the form of multiple privately owned dry ponds that are currently only activated when regular channels are full, which typically happens during 5-year rain events. The combination of these dry ponds and regular rainwater channels provides resilience for the watershed. Similarly, Ocean Bluff/ Chantrell Creek ISMP states:

The main objective of this strategy is to slowly increase the capture of a target rainwater volume, which will be filtered through cleansing materials, infiltrated into the soil to replenish groundwater, and released at a controlled rate and with a lower temperature into the drainage system. This action will achieve a reduction of the pollutant load associated to urban runoff, and will also help to regulate the discharges of stormwater runoff into the receiving water bodies (pp. 52).

The City of Coquitlam’s generally references the concept of resilience in how it aims to control peak flows to protect fish habitat and control erosion and sediment distribution.

The indicator for ‘Manage Long-term Climate Change’ considers if the ISMP encompasses a dynamic planning process that provides opportunities to adjust and improve infrastructure over time. The City of Surrey’s ISMPs were not coded for this indicator; however, through personal communications with Surrey’s research participant, the planning cycle and timeframe through which ISMPs are updated indicates that long-term climate change will be managed through the plans. The City’s of Coquitlam’s IWMPs do not explicitly state the goal of managing long-term climate change; however, through the monitoring actions outlined throughout the plans, it is evident that the plans allow for climate change to be managed over the long-term.

The indicator for ‘Promote Disaster Risk Reduction’ examines if the ISMP uses natural system solutions to reduce vulnerability to flooding and extreme heat (Travers et al., 2012). The City of Surrey’s ISMPs promote the use of LID and green infrastructure solutions, which include the use of detention ponds in parks and fields to reduce the risk of flooding. Green infrastructure provides multi-benefits, such as flood reduction, carbon sequestrations, and UHI. Similarly, the City of Coquitlam’s IWMPs regularly reference flood control, erosion reduction, public safety, and property protection as goals of their plans.

The indicator for ‘Reducing Non-climate Stresses’ explores if the ISMP minimizes other anthropogenic stresses that have degraded the condition of critical ecosystems, and thereby undermine their resilience to climate change. Such stresses include, inter alia, unsustainable harvests, habitat fragmentation, non- native species, and pollution (Colls et al., 2009). The City of Surrey’s ISMPs are closely linked to the City’s Sustainability Charter, GIN, and BCS, which aim to address non-climate stresses in the watershed. Both of the City of Coquitlam’s IWMPs aim to addresses non-climate stresses. Some areas of particular interest are improving water quality through pollution preventions and reducing flooding resulting from erosion and sediment accumulation.

***Principle: Maintaining Ecosystems***

**Table 13: ISMP Detailed Evaluation Result for Maintaining Ecosystems**

Indicator	Coquitlam	Surrey
Promote resilient ecosystems	2	1
Maintain ecosystem services	2	2

Enhancing biodiversity	2	2
Resource Conservation	2	1
Avoid Mal-Adaptation	2	2

The indicator for ‘Promote Resilient Ecosystems’ examines if the ISMP promotes resilient ecosystems and uses nature-based solutions to provide benefits to people. This involves: understanding what makes resilient ecosystems – and the services they provide and ensuring that local stewardship enhances both livelihoods and ecosystem management (Andrade et al., 2011). Surrey’s ISMPs were not coded for this indicator but it is evident through the other indicators that this is generally met throughout the ISMPs. The City of Coquitlam’s IWMPs strive to maintain or return the watershed to its predevelopment state. In addition to outlining numerous goals for watershed health, the City of Coquitlam strives to meet these goals while providing for community needs. For example, the Partington Creek IWMP states: “The IWMP process preserves watershed health as a whole, while meeting community needs and allowing development and re-development to occur. It allows for trade-offs so that environmental losses in one area within a watershed can be offset by gains in others, thereby meeting the guiding principle of no-net-loss” (HB Lanarc & Raincoast, Kerr Wood Leidal, 2011, pp. 1-1).

The indicator for ‘Maintaining Ecosystem Services’ investigates if the ISMP includes a valuation of ecosystem services, identifies the options for managing ecosystems or managing human use, and involves user communities in management actions (Travers et al., 2012). Included in the Ocean Bluff/ Chantrell Creek ISMP, the City of Surrey undertook the EMS as a science-based study to identify and map their GIN (City of Surrey, 2012). The purpose was to strategically manage ecosystems within the City of Surrey and to identify management guidelines and strategies to maximize the health and benefits of the City of Surrey’s green infrastructure through a BCS (HB Lanarc & Raincoast, Kerr Wood Leidal, 2011). Options for managing ecosystems are through LID strategies and green infrastructure. The City of Coquitlam’s IWMPs explicitly mention maintaining ecosystem services. For example, Nelson Creek IWMP states: “Maintain ecosystem integrity and support the viable development and redevelopment of lands within the watershed” (pp. 1-1). Similarly, Partington Creek IWMP states: “The watershed health tracking system used for the Partington Creek IWMP uses two indicators: (1) riparian forest; and (2) watershed imperviousness. Maintaining riparian forest and

minimizing imperviousness are the two most effective methods of preserving watershed health” (HB Lanarc & Raincoast, Kerr Wood Leidal, 2011, pp. 6-1).

The indicator for ‘Enhancing Biodiversity’ explores if the ISMPs considers the landscape prior to European settlement and seeks to mimic the original landscape and aims to provide additional or enhanced wildlife habitat for indigenous species. The Upper Serpentine ISMP explicitly states: the “[r]ecent focus within stormwater management in Surrey has been on the use of green infrastructure and source controls (sometimes called “low impact development” or LID) due to the potential to mimic natural pre-development hydrologic conditions, thus limiting negative impacts on watercourses” (pp. 56). In addition, biodiversity is an important aspect of the plan and is elaborated on more with the BCS. Enhancing biodiversity was a common theme throughout both of the City of Coquitlam’s IWMPs and was the most coded indicator.

The indicator for ‘Resource Conservation’ asks if the ISMP includes homeowner rainwater conservation practices. In this instance, the resource being conserved is rainwater. Since 1984, the City of Surrey has required all new homes to have disconnected downspouts from their roof. Water from the roof area is to be directed onto lawn areas to delay travel to storm systems and allow for infiltration. In addition, all new developments have on-site stormwater control measures. Since the late 1990’s, the City of Surrey has also required all new construction to install water meters. The City has a voluntary water meter program for older properties (Surrey’s research participant, Personal Communications, July 6, 2015). By providing meters for homeowners, homeowners now pay for the water they use, instead of a flat fee. Through paying for the service, Surrey incentivises water conservation and thus, rainwater management measures, such as rain barrels. Similarly, the City of Coquitlam has on-site rainwater management controls in place for all new developments.

The indicator for ‘Avoid Mal-adaptation’ explores if the ISMP considers the negative impacts of engineered solutions on the natural system by analyzing the impacts of the ISMP and development activities, aim to reduce negative impacts on the natural environment, and avoid inadvertent impacts on natural ecosystems and communities (Travers et al., 2012). Surrey’s Upper Serpentine ISMP states:

Goal # 10 – Address Habitat Issues Arising from Existing Land Use Activities. The Upper Serpentine River and many of its tributaries are already experiencing stresses and degradation as a result of past and current land use activities in the watershed. The ISMP will identify sections of watercourses where the habitat value has been impacted, and

will list potential approaches for rehabilitation (pp. 40).

The City of Coquitlam has focused on reducing erosion caused by peak flows from extreme rain events. The plans avoid mal-adaptation by trying to reduce hydrological and hydrogeological changes to the watershed resulting from urban development. In addition, Partington Creek IWMP identifies one of its goals as: “Strive for a no-net-loss of ecological health for the watershed as a whole measured using the Watershed Health Tracking System” (pp. 1-1).

## 6.2. Non-ISMP Document Results

Desk research was conducted in the areas of municipal stormwater and/or rainwater management, climate change planning, regional stormwater planning documents, and integrated stormwater management planning at the municipal, regional, and provincial scale. Other documents, such as Surrey’s BCS (2014) and 10-Year Servicing Plan were identified through conversations with Surrey’s research participant at different stages of the research. The non-ISMP documents reviewed do not represent all documents that could have been reviewed in this category; however, the documents include those that were sourced through desk research and identified through conversations with key stakeholders.

These documents do not meet all of the evaluation criteria as the criteria was specifically designed to explore ISMPs; however, it is still interesting to explore non-ISMP documents for a link between boarder policy, planning, and guiding documents and the inclusion of EbA principles in ISMPs. The evaluation process was based on whether or not the particular document met the criteria in the evaluation framework and not if the indicator was ISMP specific.

**Table 14: Non-ISMP Document Evaluation Result Summary**

Principles	Indicators	Municipal	Regional	Provincial
<b>Fact Base</b>				
Knowledge Based Adaptation	Climate Change As An Issue	2	2	2

	Impacts Of Climate Change	2	1	2
	Vulnerability Assessment	1	1	1
	Best Available Science	2	0	2
	Local Climate Change Projections	2	1	2
<b>Goals</b>				
Address Climate Change	Adaptation	2	1	2
Multi-scale Operations	Integration With Development Strategies	2	1	2
	Sectoral Adaption Planning	2	1	2
	Multiple Geographic Scales	1	1	1
<b>Process</b>				
Maximum Stakeholder Involvement	Stakeholder Engagement	2	1	0
	Involving Local Communities	0	1	0
	Collaboration And Trust	2	1	0
	Commitment Of Financial Resource	2	0	0
Variety	Explore A Wide Variety Of Rainwater Management Options	0	0	1
	Work With Uncertainties	0	0	1
	Understanding Trade-Offs	0	0	0
Communication	Public Education And Awareness	2	1	0
<b>Implementation</b>				
Integrating Development	Cost Effectiveness	2	1	1
	Providing Social, Economic And Environmental Benefit	2	0	2
Governance	Accountable And Transparent Decision Making	0	0	0

	Roles and Responsibilities	2	0	1
<b>Monitoring</b>				
Adaptive Management Approaches	Monitoring Timeline	0	0	1
	Monitoring Actions	2	0	0
	Manage Climate Variability	2	0	0
Resilience Building	Resilience vs. resistance	0	0	0
	Manage long-term climate change	0	0	2
	Promote disaster risk reduction	2	2	2
	Reducing non-climate stresses	2	0	2
Maintaining Ecosystems	Promote resilient ecosystems	2	0	0
	Maintain ecosystem services	2	0	2
	Enhancing biodiversity	2	0	0
	Resource Conservation	2	0	1
	Avoid Mal-Adaptation	0	0	0
<b>Totals</b>		<b>46</b>	<b>16</b>	<b>32</b>

### 6.2.1. Non- ISMP Specific Documents Results Explored in Detail

The following section explores the results of the evaluation of non-ISMP documents in closer detail. The detailed result sections are based on the principles of EbA. The score was assigned for each indicator found within the municipal, regional, and provincial documents and evidence is presented from the specific texts. The aim is to learn if documents from each jurisdiction mention explicitly, generally, or do not mention specific indicators for each principle. The criterion for each indicator is explained in *Table 1: Evaluation Framework* in Section 4.

## Fact Base

### Principle: Knowledge Based Adaptation

**Table 15: Non-ISMP Document Evaluation Results for Knowledge Based Adaptation**

Indicator	Municipal	Regional	Provincial
Climate Change As An Issue	2	2	2
Impacts Of Climate Change	2	1	2
Vulnerability Assessment	1	1	1
Best Available Science	2	0	2
Local Climate Change Projections	2	1	2

#### Climate change as an issue:

At the municipal scale, climate change is explicitly mentioned as an issue in both *City of Surrey: Climate Adaptation Strategy* (Surrey’s Adaptation Strategy) and Surrey’s BCS. Both of these documents are broad planning documents for Surrey. At the regional scale, Metro Vancouver’s *ISMP Lessons Learned to 2011* document identifies climate change as an issue that should be considered in ISMP planning; noting, “rainfall pattern changes is the most commonly considered aspect” of climate change needing to be considered in ISMPs (pp. 21). Similarly, climate change is identified as a global influence for the need to conduct watershed planning in the 2002 Metro Vancouver document: *A Watershed/Landscape-Based Approach to Community Planning*. The Guidebook identifies climate change as an issue in Chapter 1, stating: “Rain gauge data for southwestern British Columbia suggest that precipitation frequency, intensity and duration are changing compared to the mid-20th century. Research by the University of British Columbia and Environment Canada implicate global climate change as the primary contributor to these observed trends” (pp. 1-7).

#### Impacts of climate change:

At the municipal level, City of Surrey’s Adaptation Strategy addresses the impacts of climate change explicitly, and states:

If unaddressed, climate change is anticipated to significantly increase the risk of flooding in Surrey in a number of different ways. First, protective infrastructure such as sea dams and dykes are more likely to be breached with sea level rise, particularly in combination with more intense storm surges. Second, sea level rise and more frequent and intensive precipitation events may increase the frequency and duration of flooding in flood plain areas due to more frequent and intensive

precipitation events...The degree of risk is less certain regarding Fraser River freshet flooding, given the intricate dynamics of changing snowpack, rising temperatures, and shifting precipitation patterns. Some flooding and drainage impacts are already being experienced in Surrey due to climate change (pp. 39).

Metro Vancouver's *ISMP Lessons Learned to 2011* document asks municipalities if the impacts of the climate change are important for developing ISMPs; however, it does not describe what the specific impacts are but instead states that "[c]onsiderations for climate change have not been overly common to date (50% do), but when they are, rainfall pattern changes is the most commonly considered aspect" (pp. 21). The Guidebook identifies the impacts of climate change throughout, such as increased rainstorms and increased flood events.

### **Vulnerability Assessment:**

At the municipal scale, Surrey's Adaptation Strategy identifies vulnerability associated with climate change, including "more intensive precipitation events" (pp. 39). These increases in events are addressed through the implementation of ISMPs in some circumstances. At the regional level, Metro Vancouver's documents do not explicitly mention that the impact of climate change are a rationale for implementing ISMPs but asks if the impacts are taken into consideration by member municipalities. By identifying climate change as an issue, the Guidebook implies climate change is a rationale for implementing ISMPs.

### **Best available science:**

Surrey's BCS identifies many aspects of wildlife habitat and sensitive ecosystem identification, including habitat type, baseline species diversity ranking, riparian habitat modifiers, watercourse classifications, habitat suitability - the current state of biodiversity, and identified habitat's size, connectivity and condition. Regional documents were not coded for this indicator. At the provincial level, Chapter 2 of the Guidebook discusses the science behind ISMPs, such as natural vs. urban water balance, hydrology, and watershed health.

### **Local climate change projections:**

City of Surrey's Adaptation Strategy (2013) summarizes and elaborates on climate change projections. Appendix C of the strategy presents detailed climate change projections. The areas of climate change examined in the document include temperature, precipitation, and

sea level rise. The variables are examined for each and projections are given for the year 2020, 2050, and 2080. Metro Vancouver does have regional climate change projections; however, they were not coded for in this research project because they are not presented in the documents evaluated. They are however implicitly mentioned in the *ISMP Lessons Learned to 2011* document as they are posed in survey questions asked to local governments. The Guidebook provides provincial climate change projections: “Environment Canada models project increasing fall and winter precipitation, decreasing late spring-early summer precipitation, and more intense rainstorms (i.e. ‘cloudbursts’)” (pp. 1-7).

**Goals**

**Principle: Address Climate Change**

**Table 16: Non-ISMP Document Evaluation Results for Address Climate Change**

Indicator	Municipal	Regional	Provincial
Adaptation	2	1	2

As previously discussed, the City of Surrey has a specific adaptation strategy. The strategy addresses many areas of adaptation measures, including Ecosystems and Natural Areas. Surrey’s BCS, which was released after the Adaptation Strategy states: “Incorporating biodiversity and ecosystems in urban planning and design helps reduce carbon emissions and enhance adaptation to climate change” (pp. 12). Similarly, the Surrey’s 10-year Servicing Plan also references the need to incorporate climate change projections into infrastructure design and states: “all the projects are study based and are in support of the City’s Climate Adaptation Strategy” (pp. 44). The City of Surrey has been successful at integrating climate change adaptation into multiple planning documents. Metro Vancouver’s *ISMP Lessons Learned to 2011* document did ask municipalities if they considered climate change impacts in the watershed needs assessment. The document stated that approximately 50% do take climate change impacts into consideration (pp. 21). In *Integrated Rainwater Management Planning: Summary Report for ISMP Course Correction Series*, climate change adaptation was explicitly mentioned. In addition to having an entire section dedicated to explaining the climate change context for ISMPs, it also states, “Designing with nature captures the essence of climate change adaptation. As stated on page 1, adaptation is about responding to the changes that will

inevitably occur. Adaptation is at the community level and is therefore about collaboration (pp. 28).

**Principle: Multi-scale Operations**

**Table 17: Non-ISMP Document Evaluation Results for Multi-scale Operations**

Indicator	Municipal	Regional	Provincial
Integration with development strategies	2	1	2
Multiple geographic scales	2	1	2
Sectoral adaptation planning	1	1	1

**Integration with development strategies:**

The City of Surrey’s BCS identifies several other development policy documents that support the implementation of the BSC, for example, “Policy recommendations to support biodiversity are separated into categories. Many of these support and build on existing policy, including the OCP, the Sustainability Charter, and Integrated Stormwater Management Plans” (pp. 83). Successful integration of development strategies allow for the municipality to identify common goals throughout the strategies and piggyback on funding and implementation opportunities. At the regional scale, Metro Vancouver’s *ISMP Lessons Learned to 2011* document describes how integrating with land use is not always as simple as it perceived in the planning phase. It states:

Municipal staff will need to identify whether the ISMP is intended to simply support the land use plan(s) currently in place, or whether there is opportunity to amend the land use plan(s) where needed to maximize the opportunity for watershed health. Making decisions around alterations to land use can be highly political, particularly if the land use plan has been recently publicized. This is where involving Council can be of assistance. Being clear on the land use context may have a substantial effect on the scope and direction of the ISMP (Urban Systems, 2012, pp. 18).

At the provincial scale, several documents reference the integration with development strategies, including referencing other documents that promote sustainable service delivery to ensure implementation. The Guidebook identifies tools at the local government’s disposal to integrate ISMPs with development strategies, it states:

Initiating change in stormwater management through land use or site design may involve two tools of local government: the Official Community Plan (OCP) and the

Liquid Waste Management Plan (LWMP), and their related bylaw tools... Related tools are Regional Growth Strategies, Neighbourhood Plans, Zoning Bylaws, Subdivision Bylaws and Development Permits, among others. While these tools are not centered on stormwater management, the provincial Local Government Act has expressly permitted local governments to use these tools to manage environmental impacts, runoff and impervious area (pp. 4-1).

### **Multiple Geographic Scales:**

Surrey’s BCS identifies regional and local corridors for wildlife and supports the creation and maintenance of these corridors for wildlife to thrive in the region. At the regional scale, Metro Vancouver’s *ISMP Lessons Learned to 2011* document speaks to multijurisdictional implementation and states the importance for one jurisdiction to take the lead and the others to be consulted with throughout the process. At the provincial scale, the Guidebook states, “A guiding principle is to plan at four scales to ensure that solutions are both integrated and cascading. The scales are the region, watershed, neighbourhood and site” (pp. 3-5).

### **Sectoral Adaptation Planning:**

The municipal, regional, and provincial non-ISMP documents all make reference to using planners, engineers, and scientific experts to develop and implement ISMPs.

### **Process**

#### ***Principle: Maximum Stakeholder Involvement***

**Table 18: Non-ISMP Document Evaluation Results for Maximum Stakeholder Involvement**

<b>Indicator</b>	<b>Municipal</b>	<b>Regional</b>	<b>Provincial</b>
Collaboration and trust	2	1	0
Commitment of financial resources	0	0	0
Involving local communities	2	1	0
Stakeholder engagement	2	1	0

### **Collaboration and trust:**

Surrey’s BCS was created through both internal and external working groups at the city. The internal working group consisted of “key City of Surrey Staff representing the planning, parks and engineering departments along with the Office of Sustainability” (pp. 19). The external working group consisted of a “broad cross section of environmental, community,

business and development organizations and associations and First Nations” (pp. 19). At the regional level, Metro Vancouver’s *ISMP Lessons Learned to 2011* document identifies some key stakeholders that may be useful in developing and implementing ISMPs. The document mentions that Engineering typically leads the ISMP process but consultation and collaboration with Planning & Development, Parks & Recreation, and Environment also play a key role. The document also suggests engaging with Mayor and Council, Operations, Building, Sustainability, Transportation, Finance/Purchasing (pp. 12). Collaboration and trust was not coded for at the provincial level.

**Commitment of financial resources** was not coded for at the municipal, regional or provincial level.

#### **Involving local communities:**

The City of Surrey recognizes the importance of stakeholder involvement for implementing the BCS and that “the success of this Strategy will only be achieved through collaboration with private landowners” (pp. 16). Involving local communicates was not coded for at the provincial level.

#### **Stakeholder engagement:**

With the importance of stakeholder engagement to the implementation of the BCS, the project included a significant public consultation component. Public outreach and engagement activities for the BCS included:

- The establishment of a Stakeholder Working Group made up of key community stakeholders representing a wide variety of organizations, neighbouring governments and other partners;
- The creation of a staff Steering Committee that includes senior staff from key City departments that will be involved in the implementation, monitoring and evaluation of the Biodiversity Conservation Strategy;
- Ongoing communications and information sharing activities, including a project website, a project PlaceSpeak website and regular City of Surrey press releases and updates;
- A public open house and information session to share the draft strategy;
- Presentations to City advisory committees and commissions, including the Environmental Advisory Committee, Development Advisory Committee and Agriculture and Food Security Committee;
- A Corporate Report and presentation to City Council (pp. 16).

Metro Vancouver’s *ISMP Lessons Learned to 2011* document identifies the topics that local residents are most commonly engaged on, which include:

- Rainwater is a resource; identify opportunities and constraints to using rainwater more effectively;
- ISMPs provide an integrated approach (drainage, environment, planning) and strive for net benefits to the watershed;
- New / better approach to developing communities more sustainably / responsibly (liveability);
- Responsible management of municipal infrastructure;
- Meet Council goals and objectives;
- Working with and serving community;
- Preserve natural environment;
- Raise overall awareness and education;
- Protection of private property (pp. 19).

Interestingly, the document revealed that local communities are often engaged for background information and feedback on the preferred ISMP.

***Principle: Variety***

**Table 19: Non-ISMP Document Evaluation Results for Variety**

Indicator	Municipal	Regional	Provincial
Explore A Wide Variety Of Rainwater Management Options	0	0	0
Understanding Trade-Offs	0	0	0
Work With Uncertainties	0	0	0

No indicator within the principle ‘variety’ was coded for in municipal, regional, provincial non-ISMP documents.

***Principle: Communication***

**Table 20: Non-ISMP Document Evaluation Results for Communication**

Indicator	Municipal	Regional	Provincial
Public Education And Awareness	2	1	0

Surrey’s BCS explicitly mentions public education and awareness as an objective and outlines opportunities for implementation:

Community Education And Awareness Recommendation:  
 Objective: Increase awareness of local biodiversity and its importance for community Sustainability. Implement interpretive programs to support biodiversity including trail and park signage and informative displays; Promote nature and biodiversity conservation programming at the Surrey Nature Centre at Green Timbers Create and update a biodiversity webpage on City of Surrey site; Support school and summer camp programs that encourage students to learn about biodiversity and experience Surrey’s natural areas; Initiate City workshops to teach residents about nature-scaping and sustainable gardening to enhance biodiversity in

the City; Encourage community members to participate in the conservation of biodiversity through participation in events such as the monitoring program, bio-blitz, invasive species pulls etc.; Inform and educate developers and landscapers of biodiversity conservation objective (pp. 87).

At the regional level, Metro Vancouver’s *ISMP Lessons Learned to 2011* document revealed that the engagement process for ISMPs is used to raise overall education and awareness building (pp. 19). Public education and awareness was not coded for at the provincial level.

## **Implementation**

### **Principle: Integrating Development**

**Table 21: Non-ISMP Document Evaluation Results for Integrating Development**

<b>Indicator</b>	<b>Municipal</b>	<b>Regional</b>	<b>Provincial</b>
Cost Effectiveness	2	2	1
Providing Social, Economic And Environmental Benefit	2	0	2

### **Cost effectiveness:**

At the municipal scale, Surrey’s 10 year Servicing Plan provides a summary of the cost requirements for implementing drainage services, which include ISMPs. At the regional scale, Metro Vancouver’s *ISMP Lessons Learned to 2011* document identifies potential sources of funding for member municipalities to pay for ISMPs. The list includes: general revenue, dedicated drainage funding, stormwater utility, development cost charges, and external grant or funding source (Urban Systems, 2012, pp. 10). It also provides an estimated typical budget for ISMPs per hectare (pp. 8). Budgets range from \$50,000 to \$250,000.

The *Integrated Rainwater Management Planning: Summary Report for ISMP Course Correction Series* provides a cost estimate for the Metro Vancouver Region and discusses the importance of integrating ISMPs into broader watershed development goals:

The scale of the ‘ISMP money issue’ is illustrated by the Metro Vancouver situation. The region has 130 watersheds. Based on typical costs generated by ISMPs to date for traditional ‘pipe-and-convey’ infrastructure, continuation of the old-business-as-usual could potentially result in an aggregate cost to the region that could easily be in the order of ~\$1.4B...After a decade of ISMP and related experience, a critical lesson learned is this: A drainage planning process can be expected to flounder unless

it is truly integrated with a blueprint for watershed redevelopment over time. Align efforts within a municipality. Integrate with land use and development processes. They drive the built form. A watershed vision is about the look-and-feel of the watershed landscape (pp. 1).

**Providing Social, Economic And Environmental Benefit:**

Surrey’s BCS outlines the following benefits from including ecosystem values in development plans:

- Water and air quality - natural ecological processes provide drinking water and breathable air;
- Absorption and removal of pollutants - urban trees, plants and wetlands act as a natural filter for airborne, overland and subsurface pollutants;  
Stormwater and flood management - wetlands and trees reduce the run-off impact of heavy rains and can absorb and store water;
- Temperature moderation -trees provide shade and help moderate the urban heat island effect;
- Crop pollination - bees and other pollinators are essential for crops;
- Food production - trees and plants can be important for local food production;
- Recreation - natural habitat provides opportunities for recreation;
- Human health - access to nature in urban areas reduces stress and improves psychological and physical well being; it has also been shown to increase workplace productivity;
- Aesthetic/Experiential - Trees, gardens, and natural areas are prominent aesthetic features of the urban environment; for many urbanites, they are their only opportunities to experience nature;
- Spirituality - biodiversity is a critical component of our culture and religion; it is of particular importance to First Nations (pp. 11).

The regional documents were not coded for providing social, economic, and environmental benefit. The Guidebook outlines the social, economic, and environmental benefits of ISMPs throughout the guidebook.

***Principle: Governance***

**Table 22: Non-ISMP Document Evaluation Results for Governance**

Indicator	Municipal	Regional	Provincial
Accountable And Transparent Decision Making	0	0	0
Roles and Responsibilities	2	0	1

**Accountable And Transparent Decision Making** was not coded in any documents reviewed.

**Roles and responsibilities:**

At the municipal scale, the City of Surrey's Adaptation Strategy has an explicit section for 'Roles and Responsibilities, which states:

**ROLES AND RESPONSIBILITIES:** Each adaptation action has been assigned a lead City department responsible for implementation; however, not all actions are within the jurisdiction of the City to carry out. Indeed, the role of senior governments in helping cities adapt to climate change will be critical. In these cases, City staff may collaborate with other stakeholders and look to other levels of government to implement or partner on certain actions. To clarify the sphere of influence and align with the structure of Surrey's Sustainability Charter, each action has been categorized as either: corporate operations, municipal jurisdiction, or influencing others in Appendix A. For the actions that fall within the realm of corporate operations or municipal jurisdiction, actions may be tied into departmental plans and budgeting processes. The lead department will work with the other supporting departments, using identified planning and policy tools, with an emphasis on the priority actions highlighted for immediate implementation. The full list of actions with other implementation considerations including supporting departments, policy tools, and relative cost can be found in Appendix A (pp. 89).

In addition, it also has a section specifically describing the roles and responsibilities for incorporating adaptation through ISMPs:

**Goal 4: Protect Ecosystem Services through Development Adaptation Action.**  
Incorporate climate change into the City's Integrated Stormwater Management Plans (ISMPs) and other efforts to integrate land use planning and stormwater management  
Provide direction to developers on suitable vegetative species and development features that enhance habitat values  
Host workshops for the City's staff, management and Council on 'green' development features and their effectiveness in protecting ecosystem services  
Review landscape design guidelines to ensure they support habitat values  
City Lead Engineering (pp. 61).

The regional documents were not coded for the 'roles and responsibilities indicator.'

The Guidebook clarifies why ISMPs are within municipal jurisdiction as they are integral for water quality and fish habitat:

Local government has responsibility for land use decisions. Local government is also responsible for protection of property. Because of the direct relationship between land use development and stormwater impacts, local government must play a primary role in aquatic habitat protection and restoration related to stormwater management. Recent changes to the Local Government Act have expanded the mandate for municipalities and regional districts to manage runoff and impervious area. In view of the expanding role of local governments in stormwater management, a key objective of the Guidebook is to provide a pragmatic, integrated and science-based approach to stormwater planning. This will enable local governments and landowners to make long-term land use and development decisions with more confidence (pp. 10-9).

## Monitoring

### Principle: Adaptive Management Approaches

**Table 23: Non-ISMP Document Evaluation Results for Adaptive Management Approaches**

Indicator	Municipal	Regional	Provincial
Manage Climate Variability	0	0	1
Monitoring Actions	2	1	0
Monitoring Timeline	2	0	0

#### Manage Climate Variability:

Municipal and regional documents were not coded for the ‘manage climate variability’ indicator. The Guidebook states: “[The ISMP] must also have a feedback loop so that adjustments and course corrections can be made over time” (pp. 6-1). This is a broad statement but important as it embodies the essence of an adaptive management approach.

#### Monitoring Actions:

At the municipal level, the City of Surrey’s BCS identifies ecological indicators, including indicators species that are easily monitored in Surrey. The BCS also references the City’s Sustainability Strategy and City Biodiversity Index as a source for recommended objectives, criteria and indicators. The details of the indicators are outlined in numerous appendices in the document. At the regional scale, Metro Vancouver’s *ISMP Lessons Learned to 2011* document identifies what types of data collection municipalities are conducting:

##### Data Collection Facts and Figures

- Those who have flow monitoring programs in place on a community wide basis; 7 of 15.
- Those who have water quality monitoring on a community wide basis; 5 of 15.
- Those who have a benthic sampling program on a community wide basis; 5 of 15.
- Those who collected flow data as part of ISMP; 7 of 13.
- Most popular flow monitoring period is one year or more.
- Those who compute the Riparian Forest Integrity (RFI) index; 4 of 14.
- Those who compute effective impervious area (EIA); 9 of 14 (pp. 15).

### **Monitoring timeline:**

At the municipal level, Surrey’s BCS states: “The habitat that currently exists within the target corridor widths is summarized. About one half of the corridors are in a natural state. The other half is disturbed from development or being used for agriculture. This analysis should be undertaken every five years to evaluate the progress in achieving GIN objectives” (Pp. 67). In addition, it states: “Review and track the implementation of the GIN every two years as a part of the Sustainability Dashboard” (pp. 84). Regional and provincial documents were not coded for the ‘monitoring timeline’ indicator.

### ***Principle: Resilience Building***

**Table 24: Non-ISMP Document Evaluation Results for Resilience Building**

<b>Indicator</b>	<b>Municipal</b>	<b>Regional</b>	<b>Provincial</b>
Manage long-term climate change	0	0	2
Promote disaster risk reduction	2	2	2
Reducing non-climate stresses	2	0	2
Resilience vs. resistance	0	0	0

### **Manage long-term climate change:**

The nature of the adaptive management approaches identified the Guidebook illustrates the dynamic planning process that provides opportunities to adjust and improve infrastructure over time. The Guidebook identifies population growth and climate change as the sources to control more runoff in the future. Municipal and regional documents were not coded for the ‘manage long-term climate change’ indicator.

### **Promote disaster risk reduction:**

At the municipal scale, Surrey’s BCS identifies the connection between biodiversity and risk reduction, stating: “Stormwater and flood management - wetlands and trees reduce the runoff impact of heavy rains and can absorb and store water” (pp. 11). Metro Vancouver’s *A Watershed/Landscape-Based Approach to Community Planning* document states one of the goals of watershed/landscape-based approach to community planning is aimed at the

“protection of people and property from natural hazards” (pp. 3). At the provincial scale, the Guidebook states: “The evolving science of stormwater management has broadened the traditional engineering approach to one that integrates hydrologic and environmental concerns, and that is also proactive in managing risk. Hence, the term Integrated Stormwater Management Plan (ISMP) is gaining widespread acceptance in BC because it addresses two categories of risk management: Flood Risk – to protect life and property and Environmental Risk – to protect habitat and property” (pp. 3-3).

**Reducing non-climate stress:**

At the municipal scale, Surrey’s BCS identifies non-climate stresses including habitat loss, population growth and development pressure, damage to riparian and watercourse areas, and human disturbance and interactions. The Guidebook promotes many opportunities to reduce non-climate stresses, including reducing the Ecological Impacts on Species at Risk, reducing pollution, reducing damage to property. This indicator was not coded in regional documents.

**Resilience vs. resistance** was not coded for in any of the documents.

***Principle: Maintaining Ecosystems***

**Table 25: Non-ISMP Document Evaluation Results for Maintaining Ecosystems**

Indicator	Municipal	Regional	Provincial
Avoid Mal-Adaptation	2	0	0
Enhancing biodiversity	2	0	2
Maintain ecosystem services	2	0	1
Promote resilient ecosystems	2	0	1
Resource Conservation	0	0	0

**Avoiding Mal-adaptation:**

At the municipal scale, the Surrey’s Adaptation strategy directly addresses mal-adaptation. For example, it states:

A number of mutually reinforcing actions have been identified within Surrey’s Climate Adaptation Strategy and Surrey’s Community Energy and Emissions Plan, and are summarized in Table 2 on page 86. The linkages that simultaneously increase resilience

to climate change impacts and reduce GHG emissions can be categorized into four areas: Ecosystem Protection, Hazard Avoidance, Compact Land Use; Ecosystem Health, Carbon Sequestration; Heat Management, Passive Solar Design; Community-Based Energy Systems, Self-sufficiency... Reducing GHG emissions and preparing for the impacts of climate change are both critical components of climate action, and can have positive mutual benefits with careful planning (pp. 14).

Regional and provincial documents were not coded for the 'avoiding mal-adaptation indicator.

### **Enhancing biodiversity:**

At the municipal level, Surrey's BCS is aimed at enhancing biodiversity within the City. The document outlines Key Biodiversity Conservation Principles, which include protect critical habitat and features; enhance habitat connectivity; maximize the size of core natural areas; improve habitat quality; research; education and public awareness; regulations; community action; and ecosystem services. Most notable, however, is the explicit reference to the role of ISMPs to "mimic natural habitat and function." The document states:

Other opportunities within the Urban Matrix to support the GIN include implementation of constructed features that mimic natural habitat and functions. Examples include bioswales, constructed wetlands, stormwater detention ponds, rain gardens, green streets, permeable pavement, green roofs and walls. Many of these features replace conventional grey infrastructure (e.g. pipes, culverts, pavement) and reduce the amount of hard surface on a landscape. Surrey's Integrated Stormwater Management Plan supports the use of many of these strategies, alternatively known as Low Impact Design (LID) (pp. 74).

Regional documents were not coded for the 'enhancing biodiversity' indicator. At the provincial level, the Guidebook references how fish, particularly Salmon, habitat is improved through ISMPs.

### **Maintain ecosystem services:**

As mentioned above, ecosystem services are one of the nine Key Biodiversity Conservation Principles in Surrey's BCS. The principle states: "By conserving biodiversity, we can meet multiple objectives for human health such as stormwater management, climate change, improving air and water quality" (Diamond Head Consulting, 2014). Regional documents were not coded for 'maintain ecosystem service' indicator. At the provincial level, the Guidebook implicitly mentions maintaining ecosystem services through discussing how development has impacted water quality and comparing it to pre-development standards. The Guidebook states:

Where Rainfall Goes Before and After Development. Figure 2-1 illustrates how the Water Balance changes when natural vegetated cover is replaced by suburban development. By providing example percentages, this drawing highlights the magnitude of the additional volume of water that must be handled by a drainage system after land is cleared. The actual percentages will vary from region to region, but the relationships are universal. On an annual basis, surface runoff from a forested or naturally vegetated watershed in the Pacific Northwest is minimal as a proportion of total water volume. Before development, the flow that we observe in streams is actually interflow. After development, flow in streams typically originates as surface runoff. As a watershed is cleared, surface runoff volume increases in proportion to the percentage of impervious surface area, defined as non-infiltrating surfaces (e.g. concrete, asphalt, rooftops... (pp. 2-3).

### **Promote resilient ecosystems:**

At the municipal level, Surrey's BCS frequently references actions to promote resilient ecosystems. Some of the measures they readily suggest include: bioswales/ rain gardens, stormwater detention ponds, green streets, container planting, as well as green roofs and walls. Regional documents were not coded for 'promote resilient ecosystems' indicators. At the provincial level, the Guidebook references using healthy watershed metrics to form the baseline for biophysical targets for urban watersheds. The guidebook states:

a biophysically-based target condition must be translated into performance targets that can be applied to stormwater management practice. Since changes in Water Balance and hydrology are the primary source of stormwater related impacts on watershed health (see Chapter 2), it is especially important to establish performance targets for managing: Runoff Volume, and Runoff Rate. This section suggests that "healthy watersheds" maintain the water balance and hydrology found in undeveloped areas, which consequently ISMPs are attempting to mimic in developed areas; therefore, resilient ecosystems are promoted as natural solutions are being utilized to provide benefits to people (pp. 6-3).

**Resource Conservation:** None of the documents were coded for explicit actions that should be taken by homeowners to conserve rainwater. There are many actions through LID principles that could be implemented at both the individual property level scale or by the city.

## **Chapter 7.**

### **DISCUSSION**

This research is the culmination of an evaluative assessment of select ISMPs in Metro Vancouver for the inclusion of EbA principles. In addition, municipal, regional, and provincial policy and planning documents were reviewed for their inclusion of EbA principles. EbA is a relatively new concept and the evaluation utilized in the research was developed explicitly for this research project from a literature review and expert interviews. The evaluation was completed on four ISMPs, two from the City of Surrey and two from the City of Coquitlam.

#### **Noteworthy Results**

The evaluation was conducted in two phases: the four select ISMPs were evaluated first and the non-ISMP documents second. Overall, the results indicate that principles of EbA are implicitly included to various degrees in all ISMPs evaluated and both Coquitlam and Surrey scored relatively well for most indicators. In particular, both municipalities received complete scores for over half of the indicators, such as Best Science Available, Integration with Development Strategies, Sectoral Adaptation Planning, Explore a Wide Variety of Rainwater Management Options, Public Education and Awareness, Providing Social, Environmental Benefit, Maintaining Ecosystem Services, Enhancing Biodiversity, and Avoiding Mal-adaption. In addition, both municipalities received full scores for all indicators within the Maximum Stakeholder Involvement Principle.

The indicators where the municipalities received partial scores include Adaptation, Multiple Geographic Scales, Work With Uncertainties, Roles and Responsibilities, Resilience vs. Resistance, and Resource Conservation. In many instances, a full score was not given because there was only implicit mention of the

indicator within the ISMP. An implicit mention of an indicator does not mean that is not being met, but merely that the ISMP does not provide enough explicit detail to warrant a full score for the indicator. This is not surprising as ISMPs are intended to communicate specific information with regards to improving watershed health to an intended audience and were not designed to be meeting the EbA standards reflected in the evaluation.

The implicit identification of the indicator is still important though as it shows that principles of EbA are represented in the ISMP; however, not explicitly communicated. The indicators may not have been communicated for several reasons, such as they are elaborated on in other planning documents. Surrey's research participant noted during the second interview that maintaining ecosystems was not coded for often in the analysis but that is likely because Surrey has other documents that take the lead on maintaining ecosystems in the City. Surrey's research participant stated: "we have so many separate strategies that get incorporated so the ISMPs says they are going to follow these documents and then they don't go into detail on them...the reference documents and the ISMPs are not developed independently" (Surrey's Research Participant, Personal Communications, July 6, 2015). For example, Surrey has a whole strategy on maintaining ecosystem services and enhancing biodiversity so the ISMP does not need to focus on those topics.

The only principle that had a large discrepancy between the scores received by the municipalities was 'Knowledge Based Adaptation'. The indicators explored through the Knowledge Based Adaptation principle are: climate change as an issue, impacts of climate change, vulnerability assessment, best science available, and local climate change projections. The City of Surrey scored relatively higher than Coquitlam for these particular indicators. Surrey's high scores in this area of the evaluation are likely due to Surrey's Climate Adaptation Strategy. The strategy, written in 2013, identifies opportunities to implement adaptation actions through required infrastructure and the infrastructure renewal processes.

Surrey's Adaptation Strategy also identifies new opportunities for a "no-regrets" approach to planning adaptation infrastructure, such as green infrastructure that provides rainwater management benefits and enhances biodiversity, reduces maintenance costs, increases resilience, and improves the overall health and wellbeing

of residents. Surrey's Chantrell Creek/ Ocean Bluff ISMP illustrates the importance of having an adaptation strategy for ISMPs to effectively incorporate EbA principles. The Chantrell Creek/ Ocean Bluff ISMP states: "Climate change is an important aspect that needs to be considered as part of the ISMP. The City of Surrey has outlined a Climate Adaptation Strategy (City of Surrey, 2013a) where it is recognized that changes to the current precipitation patterns are expected, such as increases in the frequency and intensity of moderate and heavy precipitation events" (Tetra Tech EBA, pp. i). Lastly, it allows for planning projects to piggyback on funding opportunities and reduce overall capital infrastructure spending. Through the alignment of ISMPs, the 10-year Serving Plan, the Climate Adaptation Strategy, and Surrey's BCS, Surrey can meet goals in all areas through routine infrastructure upgrades and maintenance.

The results of Coquitlam's IWMPs evaluation for Knowledge Based Adaptation illustrates how ubiquitous the principles of EbA are throughout IWMPs. Knowledge Based Adaptation is the only principle where Coquitlam did not receive high scores; however, Coquitlam is achieving all other principles of EbA. The low score on this one principle is not surprising, as Coquitlam does not currently have a climate adaptation strategy to reference in their IWMPs. As it stands, Coquitlam's research participant agrees climate change projections should be acknowledged in IWMPs but secondarily, the main focus should be the watershed health, the engineering, and the environmental planning. Coquitlam's research participant explained:

"[Coquitlam], like many municipalities, are concerned about [climate change]; however, I don't feel that is within the scope of an IWMP. If we look at what the objectives are of the IWMP, [it] is about mitigating the impacts of development within each watershed. If you look at the Metro Vancouver requirements out of the Liquid Waste and Resource Management Plan, it says that all municipalities shall complete the integrated stormwater management plans for all urban watersheds, not all watersheds, meaning those where we have development and have development impacts, so the type of impacts that we will see is pollution, or erosion, or high flows, damage... those are the types of things we are trying to mitigate. So in the purest sense of a watershed plan I do not feel that climate change belongs there and that is why we didn't focus on that."  
(Coquitlam's Research Participant, Personal Communication, July 7, 2015).

Coquitlam's research participant also pointed out that Coquitlam developed their IWMPs based on the Metro Vancouver template (Chapter 9 of the Guidebook) and climate change was not included in the template. She pointed to this as one reason for

not including it in the IWMPs but also identified the impacts themselves as barriers. Coquitlam's research participant also noted the climate change impacts of

larger volumes and frequency of rain in the winter. If we look at adaptive management or rainwater management, we cannot really address that... We may need to upsize our infrastructure or build dikes, like major pieces, although rainwater management can help with some things, like base flows, pollution, and some other things, I am not convinced yet of its ability to act as a climate change tool on its own, I don't think it has that capacity (Coquitlam's Research Participant, Personal Communication, July 7, 2015).

In regards to the role of a climate adaptation strategy to define the capacity for ISMPs to address climate change, Coquitlam does not have a robust climate adaptation strategy but does have a strategy to reduce GHG emissions. Climate change is an important issue for the City of Coquitlam and secondary benefits to IWMPs, such as addressing climate change, are included in presentations to Council and are important for securing funding. Coquitlam's research participant described the approach being taken to address climate change through their work as: "For now, the position being taken in terms of the big hard fixes that we do, like raising dikes or such or changing design criteria so that we are building bigger pipes, our stance is to do work, like IDF curves, more to keep an eye on things and look at design criteria every five years and look at climate change and rain falls and see if we can adjust" (Coquitlam's Research Participant, Personal Communication, July 7, 2015).

It should be mentioned that even with an adaptation strategy, Surrey is still making adjustments to their approach to climate change adaptation regarding rainwater management. Surrey's research participant explained: "Surrey is still deciding how it is going to roll [adaptation] out in regards to rainfall changes to upland development (Surrey's Research Participant, Personal Communications, July 6, 2015). The City of Surrey has completed their own climate assessments about the increase in rainfall based on either up-scaling the trends or downscaling the climate models for Surrey's gauges and the results were alarming. Surrey is still deciding how to move forward with future development given their localized climate models. Adaptation planning requires reviewing past plans and making adjustments as new information becomes available. Regardless of having a climate adaptation strategy in place or not, both Surrey and Coquitlam are incorporating new science regarding changes to rainfall patterns into their ISMPs.

The only indicator that neither municipality scored on is Accountable and Transparent Decision Making. This indicator was looking for implicit or explicit mention that the ISMP was designed or implemented with no negative impact on vulnerable populations or sensitive ecosystems (Andrade et al., 2011). While ISMPs intend to protect vulnerable ecosystems and, in particular, vulnerable fish population and habitat, the decision making process of the steering or advisory committees were not elaborated on in the plans. When discussed with Coquitlam, Coquitlam's research participant described a scenario that indicated that careful consideration is given to vulnerable ecosystems and not communicating it within the IWMP was a communications error on their part. Coquitlam's research participant shared an anecdote from an OCP process where the City had:

had a neighbourhood centre planned because that's where planning wanted it because it was convenient for transportation and roads and the views, but it happen to be situated over three really important tributaries to a salmon bearing stream so we worked with DFO and a bunch of stakeholders (planning, engineers, environmentalists) and we actually moved the entire village centre over so that it wouldn't be impacting that area" (Coquitlam's Research Participant, Personal Communication, July 7, 2015)

Without including such examples in the IWMP, readers are not aware of the careful consideration given to planning decisions.

Similarly, for the City of Surrey, Surrey's research participant attributes the low score for Accountable and Transparent Decision Making to a communication error about how the funding for stormwater infrastructure is decided. Once the financial aspects are figured out and approved by Council, it is their department's responsibility to make the decisions in how to implement the ISMPs. Surrey's research participant explains:

The assets manager for capital, [the engineering manager, development manager, and the operations manager] are the ones with the accountability and the decision making (council obviously agrees with [the] ten year plan and annual budget) as that is how everything gets set out. We make the decisions internally for what makes it into the ten year plan based on the information we have from the watershed" (Surrey's Research Participant, Personal Communications, July 6, 2015).

Surrey's research participant elaborated further with regards to transparent decision making stating:

The City has a transparent financial process as everyone sees it when Council votes on it, it's all public, for example the 10 year Plan is all in the public domain so to me it is fairly transparent, though sometimes people will ask why we

did these projects instead of those projects other projects. Hopefully the ISMP is telling us what the most significant area that we should be jumping on is (Surrey's Research Participant, Personal Communications, July 6, 2015).

It is clear that the ISMPs may not communicate how decisions are made, but the nature of a local government means that how public funds are allocated is conducted in a transparent manner and in the end, Council and program managers are ultimately the ones responsible for the successful implementation of any plan.

## **Non-ISMP Documents**

ISMPs are a planning tool and implemented through an integrated approach; therefore, it was important to also evaluate non-ISMP documents that relate to the implementation or design of ISMPs at the municipal, regional and provincial scale. Most notable are the planning and policy documents that directly influence or reference ISMPs, such as Surrey's 10-year Servicing Plan, Metro Vancouver's Liquid Waste Management Plan, and the Guidebook. Based on the division of jurisdiction, municipal documents ranked highest for their inclusion of EbA principles, followed by provincial documents, and regional documents ranked lowest. That being said, Metro Vancouver's Liquid Waste Management Plan is one of the most significant non-ISMP document as it is this document that contains the ministerial note from the Minister of Environment that legislates all member municipalities in Metro Vancouver to develop and implement ISMPs. Interestingly, the document itself doesn't provide much guidance for the design and development of ISMPs but stresses the importance of the outcomes expected from ISMPs.

The results of the non-ISMP evaluation show that municipal policy and planning documents have the most influence for the inclusion of EbA principles. The municipal documents reviewed scored particularly high for most indicators such as, Climate Change as an Issue, Local Climate Change Projections, Adaptation, Integration with Development Strategies, Stakeholder Engagement, Cost Effectiveness, Promote Resilient Ecosystems, and Resource Conservation. Regional documents did not score particularly well for any one principle but were implicitly meeting several of the indicators. The provincial documents scored particularly well for Knowledge-Based Adaptation and Multi-scale Operations. The indicators that were not met by municipal, regional or

provincial documents were Understanding Tradeoffs, Resilience vs. Resistance, Accountable and Transparent Decision Making, and Avoiding Mal-adaptation.

## **Significance**

Metro Vancouver's ISMP process was disseminated nationally as a case study in Natural Resources Canada's *Adapting to Climate Change: An Introduction for Canadian Municipalities* (Hicks & Howe, 2014). The case study example explores the history of ISMPs in BC, climate change projections, the connection between ISMPs and adapting to climate change. The chapter states, "Although it is not driven directly by concerns about the impacts of climate change, the ISMP process provides Metro Vancouver and its members with an inclusive and comprehensive tool for managing complex risk-management issues that improve the region's capacity to deal with environmental risks, including those related to climate variability and change" (Hicks & Howe, 2014). This research builds on the assertion that ISMPs are an appropriate planning tool to address some climate change impacts related to precipitation and tries to identify if ISMPs are an appropriate tool for implementing EbA in urban areas. Based on the findings described in this report, the principles of EbA are inherently found in Surrey's and Coquitlam's ISMPs; therefore, ISMPs are useful for implementing EbA in urban areas. These results are not unexpected as the principles of EbA are well aligned with the intended outcomes of ISMPs. While the process for developing ISMPs is place based and is aimed at attaining desired outcomes as opposed to specific practices, the inclusion of EbA principles will also inherently be place-based and likely be reflective of the culture and development requirements of particular municipalities. For example, the City of Surrey exhibits a culture in support of ecosystem-based approaches. Surrey was early adopter of ISMPs and LID design principles for rainwater management, as well as, defines ISMPs as a "comprehensive, ecosystem-based approach to rainwater management" (City of Surrey, 2015c).

The findings from this research project also contribute to broader discussions of the applicability of utilizing ecosystem-based urban design practices to help cities adapt to climate change. Urban and regional planners interested in climate change adaptation will find this research particularly interesting as this project identifies rainwater management as a great opportunity for integrating EbA into urban areas, as well as,

providing evidence for ISMPs being an appropriate tool for implementing EbA. Changing the urban form can be a costly and slow process. Many regions in Canada have already experienced the negative impacts of a changing climate and are looking for innovative and cost effective planning strategies to mitigate and adapt to climate change. Finding solutions to reduce future infrastructure costs while adapting to climate change is a win-win scenario. Before local governments will commit to costly upgrades to the urban form in the name of sustainability and climate change resilience, they often require examples outlining the proven success of similar upgrades elsewhere. The City of Surrey and City of Coquitlam are already regarded as leaders in integrated stormwater planning in BC and the results of this research show they are both leaders in implementing the principles of EbA in the urban context through rainwater management. In other words, cities across the country and from around the world can look to Surrey and Coquitlam as examples as municipalities that have successfully implemented the principles EbA in the urban context.

The results of this study indicate that EbA principles can integrate with urban planning contexts, especially for sustainable rainwater management that is responsive to climate variations both present and future. This research is an important first step in understanding best practices for the inclusion of EbA in urban areas. The framework developed for this research provides a comprehensive understanding of the principles and indicators of EbA in the urban context relating to sustainable rainwater management. The next step for understanding if and how EbA is best implemented in urban areas is to assess an applied sustainable rainwater management project. Further assessment of an applied project would require building out the framework used in this project to include a metric for each indicator.

### **The importance of a ‘no regrets’ adaptation planning approach**

As previously mentioned, the costs associated with the expected natural catastrophes will cost Canadians \$5 billion per year by 2020, and \$21-\$43 billion by 2050 (NRTEE, 2011). Similarly, the replacement cost for addressing Canada’s current infrastructure deficit totals \$171.8 billion nationally, or \$13,000 per Canadian household (Felio, 2012). With approximately eight percent of every tax dollar collected going to local governments, the resources of local governments to address climate change and

improve infrastructure is limited. That being said, neither climate change nor degraded infrastructures are issues that can be ignored. Therefore, there is tremendous opportunity for local governments to adapt to climate change while making necessary improvements to local infrastructure. What's more, through thoughtful planning of capital infrastructure projects, multiple benefits beyond climate change may be achieved. For instance, Coquitlam's research participant identified reducing UHI as a secondary benefit to integrated watershed management. They explained that having rainwater returning to the ground and recharging aquifers means those areas will "probably not dry out as fast as they would if we hadn't been doing that..., [which is] going to help us mitigate our hotter dryer summers" (Coquitlam's Research Participant, Personal Communication, July 7, 2015).

Coquitlam's research participant stressed that the goals of IWMPs are directly related to improving the health of the watershed and only a few of those goals may cross over to climate change. In some instances, such as re-vegetation to reduce erosion, the climate change resilience benefits could be promoted as secondary. They explained, "I couldn't justify spending that money purely for climate change because the benefits just aren't enough, but as a secondary benefit, [improved vegetation and erosion reduction] provide benefits, food, shade for fish and if we have hotter, dryer summers, this should provide an additional benefit. You could justify it secondarily" (Coquitlam's Research Participant, Personal Communication, July 7, 2015).

From the adaptation planning perspective, identifying the additional benefits are vitally important for securing funding and approval from Council. Given the numerous uncertainties surrounding climate change impacts, local governments must proceed with caution to ensure they are spending taxpayer's money in a responsible manner and reducing the risk of property damage. Through a no-regrets approach, benefits can be achieved at various temporal and spatial scales. Achieving a no-regrets approach requires tremendous collaboration between local government departments and various levels of governments. Most large infrastructure projects require collaboration between local governments departments and ISMPs are no exception. To stress the need for collaboration from a policy perspective, Metro Vancouver's *ISMP Lessons Learned to 2011* document identifies "engineering (lead), planning and development, parks and recreation, and environment as the core municipal project team for ISMPs, and suggests

also engaging with Mayor and Council, operations, building, sustainability, and transportation and finance” (pp.12). The ISMP process has proven successful at facilitating collaboration between various levels of government in BC, as a result, and may provide the framework needed for effective and efficient adaptation planning moving forward.

## **Chapter 8.**

### **CONCLUSION**

This research provides rainwater and adaptation planners with an overview of EbA from principles to practice in BC through an evaluation of ISMPs for their inclusion of EbA principles. Climate change will have several impacts on urban areas, especially regarding increased frequency and intensity of extreme weather events. Extreme storms bring intense rain events, which drop unprecedented amounts of water on relatively impervious environments. The result is increased frequency of floods and extensive property damage. The aim of the research is to learn if ISMPs are an appropriate tool to implement EbA in urban areas and if ecosystem-based urban design practices help cities adapt to climate change.

To conduct the research, I reviewed EbA literature, ISMP guiding documents, climate change adaptation and mitigation literature, green infrastructure reports, ecology literature, as well as stormwater and rainwater best management practices literature. Through desk research, I developed an evaluative framework to assess select ISMPs for their inclusion of EbA principles based on the work of by Huq, Renaud, and Sebesvari (2013). ISMP experts and practitioners reviewed the evaluative framework. I evaluated four ISMPs, two from the City of Coquitlam and two from the City of Surrey. I used NVivo software to assist in coding documents based on the evaluative criteria. The results of the assessment were presented to key stakeholders at the City of Coquitlam and City of Surrey for discussion purposes.

The results of the evaluation showed that both municipalities are incorporating EbA principles in their ISMPs. The City of Coquitlam and the City of Surrey both scored well on the evaluation, with Surrey receiving slightly higher overall scores resulting from

meeting indicators of the Knowledge Based Adaptation principle. The higher scores for these indicators can be attributed to the City of Surrey having a city wide Adaptation Strategy that provided direction on how to meet adaptation goals through ISMPs. The Adaptation Strategy also included local climate change projections that were included in the ISMP's consideration for future precipitation conditions that could be addressed through the ISMP process.

There was only one indicator from the framework that neither municipality met, which was Accountable and Transparent Decision Making. While the decision making process may not have been transparent in the ISMP, it was explained by one of the stakeholders that the budgeting process for the ISMPs is a transparent process and once the budget is approved by council, those responsible for implementing the ISMPs have the discretion for how to best implement the plan. In addition, anecdotal evidence was given through the interviews that the considerations of vulnerable populations and ecosystems are thoroughly considered in the ISMP process; however, not explicitly mentioned in the ISMP.

The results of this research will be particularly interesting to regional and municipal stormwater and adaptation planners who are seeking ecosystem-based solutions for addressing climate change in urban areas. The four ISMPs evaluated in the research project are not only examples of successful ISMPs; but they also demonstrate that select ISMPs are already meeting the indicators for EbA. While the intended purpose of ISMPs is not directly to address climate change, the results of the research show that municipalities in Metro Vancouver are already successfully implementing the principles of EbA through ISMPs in the urban context.

### **Areas for Further Research**

This research is just the tip of the iceberg regarding the use of EbA in urban areas and answering if cities can use ecosystem-based solution to provide resilience to climate change. Other questions that still need answers include: What climate change impacts are best mitigated through ISMPs and what future actions are required? What other climate change impacts can be addressed through EbA actions in urban areas? What other planning tools are useful for implementing EbA in urban areas? What is the

best method for accounting for the additional benefits received through EbA actions to ensure a no regrets approach is adopted by municipalities when adaptation to climate change? Finally, what are the best methods for an economic comparison between EBA and traditional engineered approaches to adaptation?

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## Appendix A.

### Nvivo Coding Results for ISMP and Non-ISMP Documents

Table 26: ISMP Document Coding Results

Principles	Indicators	Coquitlam	Surrey
<b>Fact Base</b>			
Knowledge Based Adaptation	Climate Change As An Issue	0	6
	Impacts Of Climate Change	0	4
	Vulnerability Assessment	0	2
	Best Available Science	17	5
	Local Climate Change Projections	0	2
<b>Goals</b>			
Address Climate Change	Adaptation	4	9
Multi-scale Operations	Integration With Development Strategies	8	11
	Sectoral Adaption Planning	3	3
	Multiple Geographic Scales	1	4
<b>Process</b>			
Maximum Stakeholder Involvement	Stakeholder Engagement	7	4
	Involving Local Communities	2	2
	Collaboration And Trust	4	2
	Commitment Of Financial Resource	1	4
Variety	Explore A Wide Variety Of Rainwater Management Options	12	9

	Work With Uncertainties	3	4
	Understanding Trade-Offs	4	2
Communication	Public Education And Awareness	3	2
<b>Implementation</b>			
Integrating Development	Cost Effectiveness	7	3
	Providing Social, Economic And Environmental Benefit	3	4
Governance	Accountable And Transparent Decision Making	0	0
	Roles and Responsibilities	1	5
<b>Monitoring</b>			
Adaptive Management Approaches	Monitoring Timeline	6	0
	Monitoring Actions	8	3
	Manage Climate Variability	1	1
Resilience Building	Resilience vs. resistance	2	2
	Manage long-term climate change	1	0
	Promote disaster risk reduction	5	3
	Reducing non-climate stresses	6	1
Maintaining Ecosystems	Promote resilient ecosystems	4	0
	Maintain ecosystem services	13	2
	Enhancing biodiversity	21	5
	Resource Conservation	2	1
	Avoid Mal-Adaptation	5	3

**Table 27: Non-ISMP Document Coding Results**

Principles	Indicators	Municipal	Regional	Provincial
<b>Fact Base</b>				
Knowledge Based Adaptation	Climate Change As An Issue	4	0	1
	Impacts Of Climate Change	4	0	1
	Vulnerability Assessment	3	0	0
	Best Available Science	3	0	2
	Local Climate Change Projections	5	0	0
<b>Goals</b>				
Address Climate Change	Adaptation	6	0	5
Multi-scale Operations	Integration With Development Strategies	7	0	4
	Sectoral Adaption Planning	0	0	0
	Multiple Geographic Scales	2	0	3
<b>Process</b>				
Maximum Stakeholder Involvement	Stakeholder Engagement	2	0	0
	Involving Local Communities	0	0	0
	Collaboration And Trust	2	0	0
	Commitment Of Financial Resource	1	0	0
Variety	Explore A Wide Variety Of Rainwater Management Options	0	0	0
	Work With Uncertainties	0	0	0
	Understanding Trade-Offs	0	0	0

Communication	Public Education And Awareness	2	0	0
<b>Implementation</b>				
Integrating Development	Cost Effectiveness	1	0	1
	Providing Social, Economic And Environmental Benefit	1	0	0
Governance	Accountable And Transparent Decision Making	0	0	0
	Roles and Responsibilities	2	0	1
<b>Monitoring</b>				
Adaptive Management Approaches	Monitoring Timeline	0	0	0
	Monitoring Actions	3	0	0
	Manage Climate Variability	0	0	1
Resilience Building	Resilience vs. resistance	0	0	0
	Manage long-term climate change	0	0	1
	Promote disaster risk reduction	1	1	3
	Reducing non-climate stresses	5	0	7
Maintaining Ecosystems	Promote resilient ecosystems	1	0	1
	Maintain ecosystem services	2	0	0
	Enhancing biodiversity	5	0	3
	Resource Conservation	2	0	0
	Avoid Mal-Adaptation	2	0	0