Planning for Wildlife:
Evaluating Creek Daylighting as a means of Urban Conservation

by

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DEDICATION PAGE

To my Mother and Father

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS AND TABLES

ABSTRACT

Creek daylighting is the deliberate effort to reinstate previously buried watercourses to the surface either through redirection of sub-surface flows to new above ground channels, or through the re-routing of storm water runoff. Projects designed to do this have been implemented and proposed throughout North America for a variety of reasons. These reasons include, but are not limited to, perceived benefits in storm water management, downtown revitalization, or as a means to improve wildlife habitat within urban areas. The discussion in this report focuses on creek daylighting as an effective means of urban conservation – are creek daylighting projects beneficial to threatened urban wildlife by providing wildlife habitat? Criteria for urban conservation were developed through an examination of conservation and urban conservation literature. These criteria were then applied to eleven daylighting projects in North America. These projects were studied through the literature, and were chosen to represent a variety of projects, put in place for various reasons. Based on this analysis, it was concluded that few daylighting projects are effective means of urban conservation. The work does, however, suggest how, through some modification of design, creek daylighting projects may have an important role to play as both urban conservation areas and connections between urban conservation areas.

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CHAPTER 1

Creek Daylighting

1.1 Introduction

There is a movement in urban areas to rediscover connections to nature and the past that have been lost for decades. One aspect of this movement concerns buried waterways which can be returned to the surface. Known as 'daylighting' this process refers to the deliberate effort "to expose some or all of the flow of a previously covered river, creek or storm water drainage. Daylighting projects liberate waterways that were buried in culverts or pipes, covered by decks or otherwise removed from view" (Pinkham, 2000).

When buried, creeks have been blamed for such things as the sinking of houses, the collapsing of culverts and combined sewer overflows. Another effect of burying creeks is that the loss of urban waterways has lead to a subsequent loss in riparian habitat. The loss of the presence of surface water has diminished the important role that water plays in the urban environment, as waterways are no longer a prominent feature in the community. It was not always this way. In his article, "Vancouver's Old Streams" Harris (1978) invites readers to visualize Vancouver's not-too-distant past by imagining that they are standing on a busy street corner in a built-up area of the city:

> "Picture yourself standing at Hemlock and West 3rd Avenue; then close your eyes and go back to a day long ago, when this very place was a living, flowing stream. Picture the cold crystal-clear water rushing over your bare feet, the fish touching your toes. Reach over and pick a berry or brush against a fern. Look up through the thick forest canopy and see the sun trickling down among the branches. Savour the forest fragrances, the clean air...and now open your eyes again and you are standing once more on the sidewalk, looking at buildings and pavement."

The daylighting movement promises an alternative to the present method of managing urban waterways. Projects in various communities have been proposed for a variety of reasons ranging from improvements in storm water management to improvements in wildlife habitat (Pinkham, 2000). Several projects assume that wildlife habitat improvements may be an outcome of a creek daylighting project regardless of whether this is a project's primary purpose. Whether this is a true statement or not needs to be investigated, and this is the focus of discussion of this report – are all creek daylighting projects effective forms of urban conservation, or do certain project traits need to be included?

For the purposes of this discussion, the concept of 'conservation' is used as an umbrella statement to describe efforts made to improve habitat for wildlife species that are under threat (Gilbert, 1989). These species are unlikely to persist without some form of intervention. Threatened species are not only found in remote, uninhabited areas, but they can be found in urban areas as well. Examples of threatened urban wildlife species may be riparian mammal species, salmon species, or various species of reptiles and amphibians. Some urban wildlife species such as starlings, rats or pigeons are quite content to inhabit developed areas as they are – there is currently little need to expend resources on wildlife habitat for those species. For threatened species, improvements to wildlife habitat can be done through protection of existing habitat, restoration of degraded habitat, or in the case of creek daylighting, reconstruction of destroyed habitat. This focused definition of conservation as the attempt to promote improvements in the habitat of threatened wildlife underlies the remainder of this report.

As interest builds around the idea of creek daylighting and because of cited benefits to wildlife habitat, an evaluation of creek daylighting projects as a means of urban conservation needs to be performed. If creek daylighting is not an effective means of urban conservation, and it is portrayed as such, those municipalities and organizations that are considering spending resources on urban conservation may wrongly invest in creek daylighting projects. This belief may take away resources from other kinds of habitat improvements. The discussion and recommendations in this report are meant to

help those planners who are not familiar or not comfortable with ecological theory to make decisions on whether creek daylighting projects should be considered when proposing to undertake habitat improvements.

It may be that creek daylighting is an effective means of achieving other goals, such as downtown revitalization or storm water management, but this paper will only consider whether time and effort should be put into daylighting projects in the name of conservation. By examining the history of creek daylighting, where and why it has been done, and what has resulted, it will become possible to answer the question of whether creek daylighting is an effective means of urban conservation.

1.2 Methodology

The examination of the concept of creek daylighting as it applies to urban conservation was performed after eleven projects were chosen out of the literature. These projects were chosen as, in the opinion of the author, they gave a balanced representation of the approximately two dozen projects that had easily available descriptions. The eleven chosen projects are a cross section of projects from within North America, having a variety of budgets, sizes, and objectives. Information gathered from the literature on the eleven projects' plans and descriptions was used in order to evaluate whether the projects were effective attempts at urban conservation.

In order to investigate the concept of creek daylighting, a variety of projects with differing designs were included. These projects are summarized in Table 1-1, and a more detailed description of each can be found in Appendix 1. This information will be used in later sections when the projects are evaluated according to chosen criteria in order to determine the effectiveness of creek daylighting projects as a tool for urban conservation. These criteria were arrived at after surveying the literature on conservation and urban conservation in particular. The criteria are a set of general criteria meant to be used to evaluate all urban conservation attempts for their ability to provide habitat for a wide range of threatened urban wildlife species.

Table 1-1: Table summarizing example daylighting projects. These projects were chosen, as they are all North American, yet have a variety of budgets and primary objectives. Associated area is the approximate amount of green space that surrounds a given project. This area may or may not have existed before the project was implemented.

Project	Primary objective(s)	Habitat improvements	Year completed	Cost	Type	Length (m)	Associated area (Ha)	Surrounding community	Connections made
Arcadia Creek *Kalamazoo, MI*	storm water management, aesthetics	no	1995	$7.5 million US	canalization	472	0.8	dense mixed-use area (near central business district)	culvert to culvert
Cow Creek *Hutchinson, KS*	aesthetics	no	1997	$1.25 million US	canalization	244	2	dense mixed-use area (near central business district)	culvert to culvert
Darbee Creek *Roscoe, NY*	storm water management	yes	1996	$9 000 US[1]	naturalization	101	0.4	residential area	waterway to waterway
Garrison Creek *Toronto, ON*[2]	storm water management, connections to nature	no	proposed	unavailable	symbolic	proposed	proposed	dense mixed-use area	waterway to waterway
Hastings Creek *Vancouver, BC*	storm water management, aesthetics	yes	proposed	$10-12 million	naturalization	800	20	dense mixed-use area	waterway to culvert
Jolly Giant Creek *Arcata, CA*	habitat improvement, education	yes	1997	$120 000 US[1]	naturalization	49	2.4	residential area	culvert to culvert

[1] Plus donated labour and materials

[2] Project is at conceptual stages only, and as such, was not evaluated. Included here as it is mentioned in later sections.

Project	Primary objective(s)	Habitat improvements	Year completed	Cost	Type	Length (m)	Associated area (Ha)	Surrounding community	Connections made
Phalen Creek *St. Paul, MN*	aesthetics	yes	1996	unavailable	naturalization	640	17	dense mixed-use area (near central business district)	culvert to culvert
Spanish Banks Creek *Vancouver, BC*	habitat improvement	yes	1999	$80 000	naturalization	58	9.3	green space	waterway to waterway
Strawberry Creek *Berkeley, CA*	aesthetics	no	1984	$50 000 US	naturalization	61	1.62	dense mixed-use area (near central business district)	culvert to culvert
Taddle Creek *Toronto, ON*	aesthetics, connections to nature	no	proposed	unavailable	symbolic	100	0.04	dense mixed-use area (near central business district)	culvert to culvert
Thain Creek *North Vancouver, BC*	storm water management	yes	1998	$1.5 million	naturalization	200	0.3	residential area	culvert to waterway
Valley Creek *Port Angeles, WA*	mitigation	yes	1997	$1 million US[1]	naturalization	149	1.1	industrial area (near central business district)	culvert to waterway

(Brown et al, 1996; Vancouver Park Board, 1996; City of Kalamazoo, 1997; University of Toronto, 1997; Botelho, 1999; City of Vancouver, 1999b; Pederson, 1999; Wolfe Mason, 1999; City of Port Angeles, 2000; Miller, 2000; Mosquito Creek Stewardship Society, 2000; Pinkham, 2000).

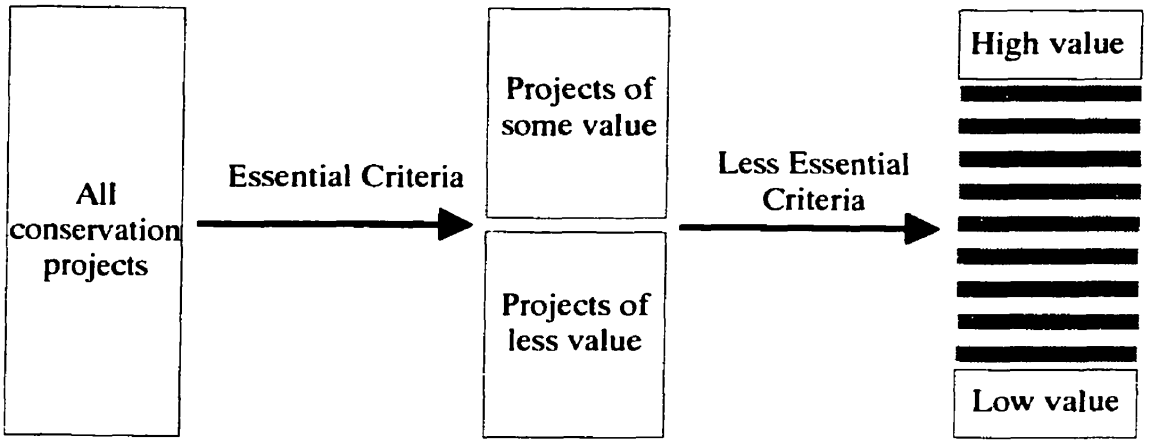

Figure 1-1: Figure illustrating how criteria can be used to assign relative values to conservation projects. Without assigning values it is difficult to decide which projects a municipality or organization should spend limited resources on.

The discussion is structured as follows. An overview of the history and terminology of the creek daylighting movement is followed by an examination of the motivations and challenges of daylighting projects. A set of general criteria is proposed to evaluate conservation areas after explaining how and why these criteria were selected from the literature. After this, a cross section of North American daylighting projects is evaluated according to the chosen criteria to see if the assumption that creek daylighting is an effective means of conservation can be made based on the outcome of the eleven project evaluations. Resulting from this is a set of recommendations and conclusions.

1.3 From Watershed to Sewershed

To understand the current movement behind creek daylighting, it is necessary to review past trends in urbanization. Urban centres generally developed around waterways as these were able to serve a variety of purposes for residents - transportation routes for goods and individuals, a source of drinking water and of food, as well as receptacles for trash and sewage. Flood plains seemed like ideal places to deposit refuse, and flowing waters quickly carried offending substances downstream. According to Leidy and Moyle (1998), aquatic systems were seen as endless sinks for municipal wastes.

The link between a clean source of drinking water and human health has not always been accepted, and for some cities, this knowledge came too late (University of Toronto, 1997). Outbreaks of disease and death were linked to urban streams that had become open sewers because of the number of people dumping sewage and refuse. Beyond being perceived as bearers of disease, urban creeks were disliked because of their unpredictability (Brown and Storey, 1996). As with most creeks, urban creeks are susceptible to flooding, partly due to seasonal changes in water level but also due to inappropriate developments both upstream and in the flood plain that reduce a watershed's ability to cope with run-off (Riley, 1998).

Instead of addressing the source of these problems, decisions were made to bury creeks (University of Toronto, 1997). Below ground these combined sewers continued to carry both municipal sewage and run-off to receiving waterways. Some cities would later require treatment of sewage, and some would take the step to separate combined sewers into two systems - one network of underground pipes servicing municipal sewage, and another network for storm water (City of Vancouver, 1999a).

1.4 Urban Stream Restoration

The past century has seen a change in the attitude of municipal governments toward urban creeks. Organizations recognizing the importance of healthy natural features, but being faced with degraded areas and watercourses, rallied around the concept of stream restoration and later, daylighting projects.

Riley (1998) details the history of the stream restoration movement in the United States from its beginnings through to the present. In the United States, sport-fishing organizations have long been involved with the cause, and pushed for legislation. This resulted in the US Fish and Wildlife Coordination Act and the US Fish and Wildlife Service in the earlier part of this century. Along with lobbying from conservation groups, soil losses during the Great Depression caused the federal government to seriously think about attempting to fix past environmental problems. Resulting from this was the Wildlife Restoration Act of 1937 that made it possible for federal assistance to acquire

and restore wildlife habitat. In addition, conservation oriented projects were seen as a way to both remediate past environmental wrongs, as well as provide employment for the many unemployed people during the Great Depression. These people would be employed in labour intensive restoration projects across the country (Riley, 1998).

The 1940s and 1950s could be known as the 'era of concrete'. It was as though the only seriously considered projects were the ones to involve massive amounts of the material. The projects that resulted from this time were not as labour intensive as in the 1930s and instead relied on heavy machinery and brute force. They have not lasted as long as earlier projects from the 1930s, and this has been linked to the forcing of 'cookie-cutter' approaches on many areas, instead of working with the unique attributes of specific projects (Riley, 1998).

From the 1960s to the 1990s restoration efforts have been boosted or starved depending on the leanings of the current government. It was not until the 1970s that the first daylighting projects were done in Napa, California and Urbana, Illinois; however, it was the daylighting of Strawberry Creek in Berkeley, California in 1984 that is credited with influencing the current initiative to daylight urban waterways (Pinkham, 2000).

In Canada, two areas (the Greater Vancouver Regional District and the Greater Toronto Area) have proposed or completed daylighting projects. Completed projects were the result of years of lobbying by such groups as the Lost Rivers Project in Toronto or various groups in Vancouver that became excited about Harris's (1978) study on Vancouver's old streams.

1.5 Overview of the Stream Restoration Process

Before briefly outlining some of the techniques that have been used by practitioners of stream restoration, some clarification of terminology is needed. The words 'creek' 'stream' and 'brook' are used interchangeably and refer to a moving body of water that is smaller than a river (Riley, 1998). Scientists have come up with another way of describing the size of waterways by referring to 'stream order'. A first order

stream is a tributary that springs from the ground. No other stream feeds into it. Its length is approximately one mile, and its watershed is approximately one square mile in area. A second order stream occurs when two first order streams meet. Its length is longer than a first order stream, and its watershed larger. This process continues up to the largest rivers in the world that are estimated at being tenth order streams (Scueler, 1995).

At a basic level, stream restoration projects often include similar physical goals – removing trash, improving base flow, reducing erosion, and increasing native vegetation. Planting native tree species on creek banks and slopes can reduce erosion as the roots hold the banks together. Erosion can also be reduced by using bank stabilizers such as rip-rap or other more engineered means. Removing trash takes only time and effort and visible improvements can be made in a short time. Improving base flow requires changes in storm water management in surrounding areas (Owens-Viani, 1997).

Creek daylighting can be seen as one aspect of the stream restoration process. Buried creeks can be seen as extremely degraded watercourses that would be subject to similar restoration techniques after being brought to the surface. Through stream restoration, degraded waterways can be made more beneficial to both wildlife and the surrounding urban community. Creek daylighting projects can include any or all of the previously mentioned restoration techniques, and this depends on the way that the creek is daylighted.

1.6 Options for Daylighting Creeks

Creek daylighting can occur in several ways. Wolfe and Mason (1999) in their proposal to daylight further sections of Strawberry Creek suggest four ways that a creek can be daylighted. These can be categorized as:

1. Symbolic representation
2. Canalization
3. Naturalization
4. No constraints

Symbolic representation – This occurs when it is not possible to daylight even a small section of a creek due to either lack of room, or lack of acceptable water. This can be done in many different ways. Suggestions from other projects have been mosaic tiles marking the former creek channel, interpretive signage, or even a shadow creek running in the old creek bed supplied by municipal water.

Canalization – This occurs when it is possible to bring to the surface the waters of a creek, but not possible to restore anything else. A concrete canal will reinstate the presence of flowing water in the urban environment but the flow is highly regulated and further restoration of the stream is not performed. By creating a canal, there may be benefits in storm water management and water quality improvements, not to mention aesthetic improvements.

Naturalization – This occurs when a creek is daylighted, some natural elements such as meanders or riffles are included in the design, and there is some attempt at re-vegetating the slopes. The flow of water is still partially controlled, and it is not possible to allow the creek full freedom of movement because of surrounding developments.

No constraints – This occurs when a creek is daylighted and no further restraints are placed on its movements or development. Further restoration, such as construction of

natural stream features or re-vegetation of stream banks might occur to help the creek achieve a dynamic equilibrium faster.

There are also differing types of connections that can be made by daylighting a section of a creek. By daylighting a section of culvert that separates two segments of a creek that is flowing in an open channel, this creates a waterway-to-waterway connection. Removing only part of a culvert that contains a buried creek can create either a culvert-to-waterway connection, or a waterway-to-culvert connection, depending on whether the daylighted section empties into a receiving body of water or returns to a culvert. A project that starts and ends at a culvert makes a culvert-to-culvert connection.

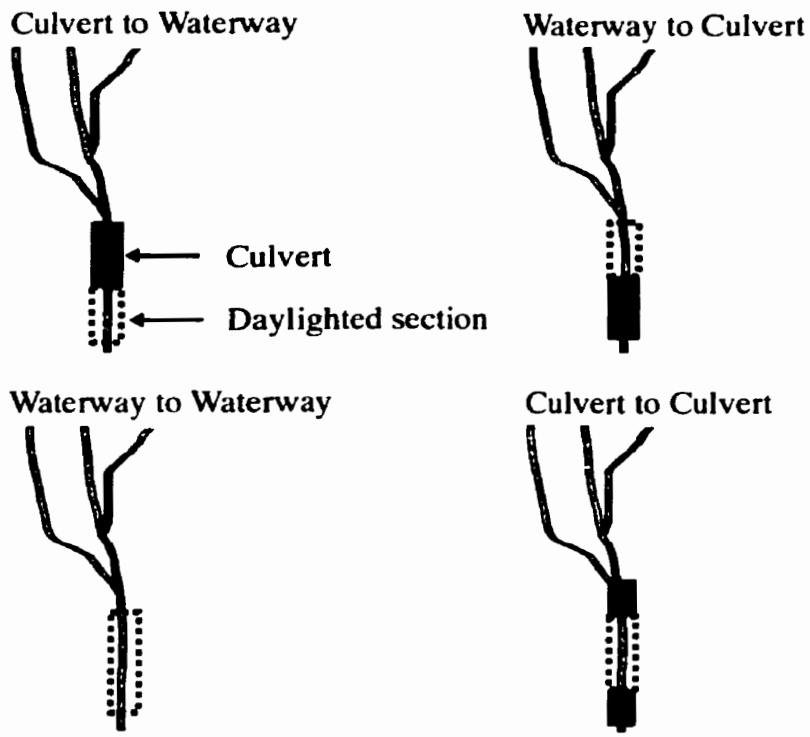

Figure 1-2: Figure showing the different kinds of connections that a daylighting project can make.

1.7 Summary

Creek daylighting is one aspect of stream restoration, a development that had slow beginnings in North America approximately a century ago. There are many ways that creek daylighting can be done, and this will result in different outcomes for wildlife habitat. The assumption that all forms of creek daylighting are an effective means of urban conservation may not be valid and needs to be tested. This will be done by examining eleven projects that are a cross section of daylighting projects from throughout North America.

CHAPTER 2

Motivations and Challenges of Creek Daylighting

2.1 Introduction

Urban conservation is not the only reason for why buried creeks have been daylighted. The motivations for why buried creeks are daylighted varies from project to project. For example, sometimes a municipality or organization is in search of a way to add an amenity to a downtown area, sometimes an engineering department perceives a cheaper way of managing flooding, or sometimes a municipality or organization wants to improve wildlife habitat – these as well as other motivations have been described by daylighting practitioners as the motivation driving a project. Each creek daylighting projects faces challenges. These challenges can be specific to bringing a buried creek back to the surface, or can be associated with any urban waterway. This chapter will first investigate the primary motivations of daylighting projects and then the challenges faced.

2.2 Motivations for Daylighting Creeks

Daylighting projects have been proposed and implemented for a variety of reasons (Pinkham, 2000). These projects are often designed with a primary objective, but project descriptions frequently list other benefits. A survey of daylighting projects through North America reveals six broad categories of primary motivations listed in no particular order:

1. Storm water management
2. Aesthetic improvements
3. Mitigation
4. Connection between people and nature
5. Education
6. Wildlife habitat

The primary objective(s) of the majority of projects surveyed were aesthetic improvements or storm water management. Improvements in wildlife habitat were also commonly listed as an expected benefit as attempts were made to include some aspect of structural diversity such as riffles or pools or native vegetation in nine out of the eleven projects surveyed (see naturalization projects in table 1-1). This is not to say that wildlife habitat improvements in urban areas are unimportant, but rather that they were simply not the primary motivators of the majority of projects. Some of the eleven projects surveyed imply that there will be expected benefits for wildlife even if habitat improvement was not the motivating factor of the project (i.e. University of Toronto, 1997; City of Port Angeles, 2000; Mosquito Creek Stewardship Society, 2000; Pinkham, 2000). Improvements in wildlife habitat may not be possible for creek daylighting projects if they are not designed that way from the start, and so daylighting projects, regardless of their primary motivation, need to be evaluated as to their value for urban conservation before this claim can be made. As previously mentioned, creek daylighting projects have been implemented for a variety of reasons. A description of each motivation and the expected results follows.

2.2.1 Storm water management

Creek daylighting has been considered by municipalities as a means of managing storm water (City of Vancouver, 1999a). Storm water management is important, as continued growth of urban areas has lead to an increase in impervious surfaces and subsequent increases in run-off after a storm (Riley, 1998). For cities without a separated sewer system but instead relying on a combined sewer system, this represents an additional burden to sewage treatment plants as both storm water and municipal sewage are treated to the same degree. By separating combined sewers and daylighting the storm water portion it would be possible to reduce the amount of sewage treated and help prevent combined sewage overflows at sewage treatment plants (City of Vancouver, 1999a).

Sometimes it is failure, or impending failure, in the city's storm water management infrastructure that causes a municipality to consider the idea of creek

daylighting. Some cities find that when considering replacing aging or inadequately sized storm sewers, a cheaper and more long-term solution would be to daylight that section of the sewer instead (City of North Vancouver, 2000; Owens-Viani, 2000; Pinkham, 2000). Over the coming decades the City of Vancouver plans to separate all combined sewers within the watershed for Hastings Creek. Instead of sending storm water to the sewage treatment plant, it will instead by used to form the base flow of Hastings Creek (Vancouver Parks Board, 1996).

Daylighting has also been implemented to reduce flooding. Under-sized culverts may be choke points in the storm water management system causing flooding upstream. Daylighting projects with a re-created floodplain can reduce flooding both upstream and downstream. Removal of choke points will reduce upstream flooding, while allowing a floodplain to flood will reduce downstream flooding through increased time to allow soil absorption (Riley, 1998). This was the case in Kalamazoo, Michigan where a history of flooding was ended when five blocks of Arcadia Creek were daylighted. Engineers now calculate that the city is protected from anything up to a 500-year flood (City of Kalamazoo, 1997). As compared to a culvert or canal, the meanders and friction of stream banks of a daylighted creek will also help to reduce the velocity, and erosive power, of storm water runoff (Ridely, 1998; Pinkham, 2000).

2.2.2 Aesthetic improvements

Another motivation for stream daylighting is for aesthetic improvements – often to add a valued feature to an urban park or downtown area through the addition of a water feature and/or the vegetation that is planted (Pinkham, 2000). The initial daylighting of a small portion of Strawberry Creek was considered such a successful draw for visitors to downtown Berkeley that a multiple block daylighting feasibility study is in the works (Wolfe Mason, 1999). After daylighting Arcadia Creek, the City of Kalamazoo in California now estimates that annual property taxes in the area of the redevelopment have risen from $60 000 US to $400 000 US and that associated economic output from a new festival site near the creek is approximately $12 million US annually (Pinkham, 2000).

2.2.3 Connection between people and nature

The Garrison Creek Linkage Project, as described by Brown and Storey (1996) proposes to physically join a series of open spaces in Toronto, Ontario based on the former channel of Garrison Creek. In a description of the Garrison Creek Linkage Project, Rosenberg (1996) suggests that the project is important in that it reinstates the important presence that water once had in the urban environment. According to Rosenberg (1996):

> "...a vast system of underground pipes makes water appear magically at the turn of a faucet. Lost are the physical traces of water, along with the visual connection to its source and distribution. Water has consequently ceased to play a meaningful role in the design of cities."

The daylighting of Garrison Creek would showcase the role natural systems can play within urban areas. As quoted in Rosenberg (1996), Jackson, (1984) suggests that modern city dwellers can only understand the value of natural systems by making comparisons with the usefulness that they attribute to man-made structures. After making this connection, it is possible to see the urban landscape as a functioning system and the value of natural systems can then be appreciated (Jackson, 1984 in Rosenberg, 1996).

The daylighting of Hastings Creek in Vancouver, British Columbia is one part of a larger project to highlight the importance of water to the Pacific Rainforest Ecosystem of which Vancouver is a part. The collected storm water that will flow in Hastings Creek will complement a series of structures in a 'rain garden' where water, especially rain water, will be the primary focus (Vancouver Parks Board, 1996). It is hoped that this project will help people realize the connections that both they and the City of Vancouver have with the environment.

2.2.4 Education

Schools are sometimes the primary instigators behind a daylighting project (Pinkham, 2000). There is a lot that can be learned from the process, and there is benefit to having an outdoor aquatic laboratory within easy walking distance to the classroom.

Arcata High School proposed daylighting a section of Jolly Giant Creek in Arcata, California and with the help of an aquatic ecology class at Humboldt State University, it happened (Ekman and Murphy, 2000; Pinkham, 2000). The outdoor laboratory at the high school has been used by many students, some of which have gone on to further studies in the field of aquatics (Pinkham, 2000). For Blackberry Creek, daylighting occurred after an earthquake damaged a culvert running under Thousand Oaks Elementary school. Instead of repairing the culvert, the school created an outdoor classroom and is now a 'magnet' school, drawing in students who want to participate in the school's ecological programs (Pinkham, 2000).

2.2.5 Mitigation

Daylighting has also been used in an attempt to balance the effects of destroying other habitat. The port of Port Angeles assisted in the construction of an estuary for Valley Creek after a company proposed to fill in an existing pond on their property. The State of Washington required mitigation for the loss of habitat contained in the pond, and so the idea to daylight a section of Valley Creek was born (Pinkham, 200).

2.2.6 Wildlife habitat

Spanish Banks Creek in Vancouver, British Columbia is one of two projects surveyed that stated that the project was undertaken specifically to improve wildlife habitat (the other project being Jolly Giant Creek in Arcata, California). In this case, project designers hoped to improve habitat as well as fish access to the upper reaches of the watershed (City of Vancouver, 1999b). Other projects such as Phalen Creek, in Minnesota, Valley Creek, in Washington, Hastings Creek, in British Columbia, or Thain Creek, also in British Columbia, are several example projects that listed habitat improvements as expected secondary benefits.

2.3 Challenges for Daylighting Projects

Daylighting projects are not without challenges. Reintroducing a stream into an urban area involves all of the issues associated with any urban stream as well concerns specific to daylighting projects. These concerns may be physical in nature, but some of the problems encountered in the past have revolved around a community's perceptions of expected outcomes. A list of challenges, in no particular order, could include the following:

1. Pollution
2. Stream dynamics
3. Safety
4. Loss of other amenities
5. Costs
6. Gentrification
7. Community acceptance
8. Habitat

2.3.1 Pollution

The quality of water that flows in urban areas is often lower than in less developed places. Rain washes contaminants such as hydrocarbons, heavy metals, pesticides, fertilizers and other chemicals, along with biological contaminants such as feces from pets and urban wildlife off surfaces and into the waterways. The added warmth of runoff from heated surfaces can itself be seen as a potential contaminant for watercourses. These contaminants can enter waterways directly or indirectly, via storm sewers that discharge into open waterways, resulting in degraded stream conditions, and pollutant levels that can become so high as to poison aquatic life (Riley, 1998).

However, projects have been designed which recognize the potential problems of non-point source pollution. For example, Hastings Creek in Vancouver, B.C. proposes to include a system of bio-filtration ponds designed specifically to remove pollutants from the storm water and improve over all water quality (Vancouver Parks Board, 1996)

In addition to non-point source pollution, urban waterways must contend with point source pollution. Sometimes toilets are incorrectly connected to the storm water system instead of the municipal sewage system, resulting in sewage flowing directly into receiving waterways (Kirkby, 1997). More than toilets have been incorrectly connected to the storm sewage system - a townhouse complex in Vancouver, B.C., was responsible for at least one major fish kill as its swimming pool was draining directly into a storm sewer that lead to a nearby creek (Kirkby, 1997).

2.3.2 Stream dynamics

A stream is not static but is in constant state of dynamic equilibrium – changing volumes and flow rates, and even the stream course, with the season, day or hour (Riley, 1998). This is the case with natural streams, and may become the case with streams that are daylighted. Before, during, and after construction of urban areas, a nearby stream will also respond to changes in runoff volume and velocity, loss of vegetation and changes in sediment load (Riley, 1998). Inclement weather or inappropriate upstream developments may cause such events as flooding or lateral movement, resulting in increased erosion and perhaps property damage (Riley, 1998). Daylighting project designers must be aware of possible changes that a daylighted creek can do to its surrounding environment, as they are the ones who introduced this potentially troubling element to the surface. Due diligence should be shown so that project designers do not become liable for damage caused by a daylighted creek.

2.3.3 Safety

As with all natural areas, there is a risk of harm to the individual because of accidents. With open water, this can include drowning. Daylighted creeks are not immune to this problem. Safety is a common fear brought up when the idea of daylighting has been proposed, but according to Wolfe Mason (1999), there have been no drownings at Strawberry Creek since it was daylighted in 1984, even with hundreds of visitors each day.

2.3.4 Loss of other amenities

There is a fear that a daylighted creek will take away space from other amenities. For this reason, most creek daylighting projects that have been completed or proposed are on publicly owned land. For example, the community surrounding the Blackberry Creek project in Berkeley, California was opposed to plans in which a daylighting project would replace antiquated playground equipment. As the equipment had to be removed for safety reasons, the community eventually came to support the idea of daylighting (Pinkham, 2000).

2.3.5 Costs

Daylighting projects are not cheap. Multi-million dollar projects have occurred and are currently proposed (Vancouver Parks Board, 2000; Pinkham, 2000). High costs of implementation and maintenance are not unique to daylighting projects. The large price tags become a challenge when a project does not perform as expected. As there are questions about the suitability of creek daylighting projects for particular objectives, a municipality or organization must be clear as to what can be expected from a daylighting project. As no city or organization has unlimited funds, choices must be made, and if a municipality or organization is to undertake a daylighting project, something else must be put on hold or forgotten altogether. There is also a social equity question to be answered as the city must decide if it is beneficial to spend millions of dollars on improvements in one park while foregoing projects in other areas of the city.

The expenditures on daylighting projects do not end once the creek has been surfaced. Maintenance is needed in order to prevent undesirable elements, such as non-indigenous species, from becoming established, as well as to fine-tune the project's design after the water body has experienced freedom of movement (Pinkham, 2000).

2.3.6 Gentrification

Waterways and green spaces are known to increase property values over the same property without such natural areas (Riley, 1998). In fact, some low-income communities have pursued stream restoration as a means to do just that (Riley, 1998).

Community revitalisation is not a bad thing - it becomes a problem when an area becomes gentrified. Property taxes in Kalamazoo, Michigan escalated dramatically for businesses and residences near a daylighting project after property values increased (Pinkham, 2000). Although Pinkham (2000) did not mention if this caused migration of businesses and people out of the project area, the potential effect of gentrification should be a concern for those proposing daylighting.

2.3.7 Community acceptance

Communities where daylighting projects are proposed can be sceptical about the idea due to the concerns listed above. According to Wolfe Mason (1999), some even wonder why anyone would want to remove a perfectly good culvert. This is part of the initial inertia that daylighting projects face in many communities as residents have trouble understanding the idea. It is hard to imagine a flowing creek when there is currently no sign of water (Pinkham, 2000).

Community members sometimes fear that daylighting a creek is not only unnecessary, but unwanted, because of potential elements that may become part of their neighbourhood when a creek is daylighted. A common worry that surrounds daylighting projects is that after implementation, the creek will become home to things that a community may believe are undesirable – rats and mosquitoes often being mentioned (Pinkham, 2000). In addition, some community members believe that daylighting projects may attract uninvited people to their neighbourhood. Homeless people have found the accessibility of a daylighted section of Codornices Creek in Berkeley, California to their liking and sometimes camp at that location despite being not welcomed by the surrounding community; however, the issue of homeless is much larger, and is not unique to daylighted creeks (Pinkham, 2000).

A community may not find the vegetation used to revegetate a daylighting project aesthetically pleasing. Complaints surrounding stream restoration projects often involve the 'scraggly' nature of the vegetation immediately after planting; however, trying to introduce more mature vegetation to appease residents has not been as successful from a

restoration stand-point (Owens-Viani, 2000). For example, the community of Maple Valley, Washington was not initially impressed with the natural vegetation used to vegetate a daylighted section of Jenkins Creek, having wanted a more landscaped experience with flowering exotic plants (Pinkham, 2000).

2.3.8 Habitat

Daylighting projects may not be an ideal form of wildlife habitat. There are several concerns revolving around connectivity issues, the effect of storm water on aquatic ecosystems, the unreliability of urban stream base flows, and ethical issues surrounding restoration projects that will be addressed in full in later chapters. According to Ken Hall, a UBC environmental chemist, as quoted in Kirkby (1997), it will not be as easy as "...to simply carve-out a long-buried creek and send out invitations to salmon in search of a new spawning address." Concerns in regards to the effectiveness of creek daylighting projects as urban conservation areas will be addressed in full in chapter 3.

2.4 Summary

There are common challenges faced by proposed and implemented daylighting projects. Initially, the community, including some representatives of the municipality, does not usually fully understand the idea and so can only see the problems that a buried creek might pose if it is brought back to the surface. After these qualms are settled and a buried creek is raised, the project can begin to do what it was designed to do. A daylighted creek may be a part of effective storm water management or downtown revitalization, but what is of interest to this discussion is whether creek daylighting is an effective means of providing habitat for threatened species of urban wildlife. This will be covered in the next chapter.

CHAPTER 3

Creek Daylighting as Urban Conservation

3.1 The Value of Creek Daylighting

Though only a few daylighting projects are specifically designed to create urban wildlife habitat, some projects suggest that a secondary benefit of creek daylighting would be improvements in habitat. It is not clear whether creek daylighting projects are an effective method of urban conservation on which municipalities should spend time and money. Daylighting projects have frequently been portrayed as being a benefit to urban wildlife, but without evaluating their value as urban conservation, it is uncertain if this is a true statement. This chapter presents a discussion of what constitutes effective urban conservation, suggests how different projects can be compared, and devises a set of criteria to evaluate the effectiveness of creek daylighting as urban nature conservation.

3.2 Urban Nature Conservation

Conservation of threatened species is an important issue for planners to consider, as it is because of land-use planning decisions that species are in need of conservation at all. Planners guide the decisions over which areas will be developed and how they will be developed. Through their decisions, they directly or indirectly decide which species will flourish and which species will languish.

When lands are developed, existing habitat is destroyed or altered, though some species may find the resulting landscape viable habitat. When speaking of urban wildlife and urban conservation areas, a distinction must be made between wildlife that will flourish regardless of the existence of urban conservation areas, and those species that will not persist without a form of refuge (Gilbert, 1989). It is those species that are under threat that are of interest to those people involve with urban conservation areas.

A decision could be made to simply let threatened species fade away. This decision would imply that wildlife has no place in urban areas; however, it has been argued that wildlife does have an important role to play in the built environment. Two differing arguments as to why urban wildlife species are valuable have been proposed and they can be distinguished by whether wildlife is valued for instrumental or intrinsic reasons. An instrumental approach to conservation would place value on those species that are perceived to be of some use to humans, while an intrinsic approach to conservation would strive to protect all species in need of protection, regardless of perceived use. Instrumental value and intrinsic value need not be exclusive. A species can be of value to people, and can be intrinsically valuable. This is true for urban wildlife species as well.

There have been various approaches by people in order to provide a home for wildlife within urban areas. Some attempts set aside lands that are largely left alone (Adams, 1994). They are not manicured and managed to the extent of other green spaces. These areas are primarily for passive recreation and so management tactics and objectives may not be such as to allow threatened wildlife to find habitat there. Other people may be more active in attempting to provide or protect habitat. They may set aside lands specifically in order to provide habitat (Adams, 1994). People may even decide to go a step further and attempt to restore or re-create wildlife habitat (Tait et al, 1998). Stream restoration would be one example of this where a municipality invests time and effort in improving degraded riparian habitat. Creek daylighting would take this process one more step by attempting to create habitat where none currently exists. Whether creek daylighting projects are effective at doing this needs to be examined.

As a municipality's resources are limited, planners and politicians must decide what type of urban conservation areas they will invest in, and what projects will occur there (Kendle and Forbes, 1997). If creek daylighting is not an effective means of conserving threatened species of urban wildlife they should not be portrayed as such, and by doing so take away resources from other efforts. The effectiveness of creek daylighting as a means of urban conservation will be discussed below.

3.3 Evaluating Conservation Areas

Several authors have discussed desirable components of conservation areas (for example Ratcliffe, 1977; Tait et al, 1988; Carr and Lane, 1993; Eagles, 1994; Kendle and Forbes, 1997). Ratcliffe (1977) suggests 10 criteria to be used when comparing the value of protected areas in the United Kingdom. Although these criteria were not specifically referring to urban conservation areas, they can with some modification, be applied to an urban setting (Kendle and Forbes, 1997). As recorded in Ratcliffe (1977) these are:

1. Size – importance to nature conservation generally increases with size
2. Diversity – variety is better than uniformity, species richness is better than a poor species complement. Sites with a range of habitats are preferred (but rarity or interest need not coincide with diversity)
3. Naturalness – sites which have been least modified by man are most valuable
4. Rarity - sites are more valuable if rare species or communities are present
5. Fragility – fragile communities are more valuable and deserving of protection. They may be vulnerable to internal changes, e.g. low population numbers causes die out, or successional change, or vulnerable to external change, e.g. by human action
6. 'Typicalness' – one objective is to maintain examples of all habitat types, good examples are as important as rare ones
7. Recorded history – sites which are well researched or documented are more valuable
8. Position in an ecological or geographical unit – this relates to landscape ecology, for example a wood which is contiguous with other woods is more valuable than one which is not
9. Potential value – sites with diminished importance, but not irreversible decline, can have a potential value greater than present value
10. Intrinsic appeal – this often applies more to species than habitats. Birds and flowers are more conspicuous and appeal more to people (Ratcliffe, 1977).

3.4 Evaluating Urban Conservation Areas

Ratcliffe's (1977) list of criteria was intended for less developed areas such as rural countryside, not the dense developments that occur in cities (Gilbert, 1989). By reviewing urban conservation literature written after, but borrowing from Ratcliffe (1977) it becomes possible to develop a list of appropriate criteria and use these as a means to assign relative value to differing conservation attempts – creek daylighting being one type of conservation attempt.

Kendle and Forbes (1997), in an analysis of urban conservation areas, agree in part with Ratcliffe's (1977) criteria; however, they group the criteria differently and put much less emphasis on some. They suggest that there is still value in a natural area that is low in diversity, as there is value in public enjoyment and education, even if it takes place in a low diversity environment (Kendle and Forbes, 1997). Natural areas should strive for levels of diversity that is representative of what is typical for the area. Some areas typically have low levels of diversity in an undeveloped state.

Ratcliffe's (1977) criterion of diversity suggests that those areas that contain the highest numbers of species are the most valuable. This concept is not valid for urban conservation areas, and is falling out of favour in other conservation management areas as well (Kendle and Forbes, 1997). A large number of species in a given area does not imply that the objective of conservation has been met. As stated previously, conservation is not about preserving all species, but rather, an attempt to halt the decline of threatened species. In addition, areas that are believed to be biologically diverse because of the large number of species present may in fact be infested with exotic and non-native species that may be of little use to native wildlife (Meffe and Carrol, 1994).

In addition to diversity, rarity and fragility are also removed as criteria. These types of habitat and species are likely to have disappeared from urban areas long ago as only those habitat and species that can currently withstand some measure of urban disturbances are likely to be present in any number (Kendle and Forbes, 1997). Although these more robust species may be present, their numbers are likely under threat and it is

these species that are in need of conservation efforts. In agreement with Kendle and Forbes (1997), Ratcliffe's (1977) criteria of rarity and fragility will not be used to evaluate the effectiveness of creek daylighting projects as urban conservation areas. This is not to say that if present rare and fragile habitats and species should not be conserved, rather that the presence of such things is not a useful tool to distinguish among urban conservation areas.

By modifying Ratcliffe's (1977) criteria, and after surveying several texts on landscape ecology, conservation biology, reserve design, and urban nature conservation (MacArthur and Wilson, 1967; Ratcliffe, 1977; Smith and Theberge, 1986; Tait et al, 1988; Noss, 1992; Simberloff et al, 1992; Malanson, 1993; Carr and Lane, 1993; Meffe and Carroll, 1994; Caughley and Gunn, 1996; Kendle and Forbes, 1997; Ehrenfield, 2000) eight criteria were chosen in order to evaluate the potential for urban conservation areas to provide habitat for threatened species of urban wildlife (Table 3-1).

These are general criteria meant to assign relative value to urban areas based on their ability to provide habitat. As general criteria, a coarse filter approach is assumed. Projects that met the criteria are expected to benefit a wide range of threatened urban wildlife species. A more fine filtered approach to conservation would use specific criteria designed to evaluate urban areas based on their ability to provide habitat for particular species (Meffe and Carrol, 1994).

Table 3-1: The general criteria chosen to evaluate urban conservation areas can be broken down into categories: essential criteria vs. non-essential criteria, and biotic criteria vs. human criteria. Whether a project passes a particular criterion is determined by the answer to the respective of questions.

1. Structural diversity	▪ Does the conservation area contain physical variety in its structure?	Essential Criteria	Biotic Criteria
2. Inclusion of buffers	▪ Does the conservation area include adequate protection from external disturbances?		
3. Connectivity	▪ Does the conservation area have a place in a larger network of viable habitat?		
4. Naturalness	▪ Is the conservation area heavily modified by humans?	Less Essential Criteria	
5. Typicalness	▪ Is the conservation area representative of habitat found in the area?		
6. Management and monitoring	▪ Does the conservation area have any management or monitoring?		Human Criteria
7. Involvement	▪ Does the conservation area involve the community in its implementation and/or management?		
8. Recorded history	▪ Does the conservation area have any recorded history?		

The listing of these criteria is intentional, from those criteria that are essential to effective conservation areas, to those that are still important, but less essential. The category of essential includes those aspects that must be present for a conservation area to provide quality habitat to a wide range of urban wildlife species. If a project fails on any essential criteria, regardless of its scoring on others, the conservation attempt will be ineffective. Without these essential aspects, there is little hope that the conservation area will be able to achieve this mandate.

The category of less essential recognizes that there is still some value in those urban conservation areas that fail some of these 'less essential' criteria. In the case of less essential biotic factors (naturalness and typicalness) conservation areas that fail these criteria may be able to support a limited number of species, but not as many (or not as likely) as those areas that pass these criteria. The other less essential criteria, the human criteria of management and monitoring, recorded history, and community involvement, do not directly measure habitat quality, but rather a municipality's or surrounding community's response to a conservation area. These criteria are still important, as they may be useful in indicating the long term sustainability of quality habitat; however, there is the possibility that quality habitat may occur even if an area fails these criteria – although it is not as likely as if the projects pass the criteria – and so these criteria are deemed 'less essential'.

3.5 Essential Criteria for Urban Conservation Areas

There are essential aspects of urban conservation that must be present for a given area to be effective at protecting threatened populations of urban wildlife. These aspects would be structural diversity, sufficient buffering, and connectivity. The other criteria described later are not unimportant to urban conservation, rather, these cannot compensate for failures in essential criteria.

3.5.1 Structural diversity

As stated previously, high levels of biological diversity may not be an appropriate goal for urban conservation areas; however, it is foreseeable that an urban conservation area would be able to create and/or maintain a variety of habitats by making increased structural diversity a goal. Structural diversity can be measured by whether there is variety in the physical make-up of a conservation area. By increasing the number of available habitats, there is a greater likelihood that there will be a corresponding increase in the number of species that are able to locate there (Caughley and Gunn, 1996). Without structural diversity, there is no reason to believe that threatened species will be able to persist, and so this criterion is very important.

3.5.2 Buffers

When speaking of size and shape of conservation areas, a key part of the discussion concerns sufficient buffers. Buffers can limit disturbance to internal areas if they are large enough. Within urban areas, external disturbances are common, and so buffering becomes an important element of any conservation area. The size of the conservation area is a determining factor over the number of species that will be able to become established there (MacArthur and Wilson, 1967; Adams, 1994) and this is partly due to the buffering of the core from external disturbances by the outside sections of the conservation area. The shape of a conservation area is also important as it determines the amount of edge to core space, or looking at the problem another way, the amount of buffering that is needed to protect core space.

When using a coarse filter approach to conservation, it is useful to use some standard of measurement. Scueler (1995) proposes a standard buffer width of 30 metres. By using a general standard, it is possible to quickly determine if adequate buffering is in place, regardless of the type of buffer or the nature of the external disturbance. Those conservation areas that are able to provide some measure of core space are likely to support a greater variety of threatened species as it is those species that are likely to be more adversely affected by human influence and disturbance (Meffe and Carrol, 1994; Kendle and Forbes, 1997). This means that when comparing two equal area conservation zones without sufficient buffers, the one that is more linear would support less undisturbed habitat, while a circular one would support more.

A fine filtered approach to evaluating conservation areas would be able to determine a more specific buffer width as well as determine the buffer's physical structure. When looking at habitat for a specific species, the species may not need such a wide buffer, or may require a particular type of buffer for particular types of disturbances. As stated previously, a coarse filtered approach was used in determining the criteria and how they would be used in order to evaluate urban conservation areas for a variety of wildlife species. Therefore, if regardless of how a project rates according to the

following factors, it will not be effective if it fails to include sufficient buffers. The minimum buffer width that will be used in this evaluation is thirty metres.

3.5.3 Connectivity

A protected area's location within a larger context is an important indicator of its ability to provide wildlife habitat (Noss, 1992). Many species are wide ranging and require diverse habitats in order to survive (Noss, 1992; Meffe and Carrol, 1994). For long term duration of a population of threatened species, they must be able to freely move to other areas. If they cannot, eventually the population will encounter conditions in which it cannot persist.

For linear systems such as riparian areas, serving as a wildlife corridor between two other habitats may be its primary function. The corridor itself may not be great habitat, but the connections it makes to other habitats are beneficial to wildlife. Therefore, for creek daylighting projects, if they do not provide connections between other habitats to allow for freedom of movement both into and out of the project area, because of culverts either upstream or downstream of the project, then they will be considered to have failed this criterion.

3.6 Less Essential Criteria

These criteria are still important for the long-term protection of threatened species of urban wildlife; however, if a project fails any of the previously listed essential criteria, there is little reason to believe that it can be considered as effective urban conservation. A completely effective conservation project would need to include all five of the less essential aspects, as well as the three essential aspects of urban conservation. Some of these criteria do not relate to the urban conservation area itself, but rather to how the municipality and the surrounding community react to the area. These may not initially seem to be effective criteria to use to evaluate urban conservation areas as they are more 'human-oriented'; however, because of the large effect that people have on urban areas, these factors cannot be left out. If people do not believe in the goals of a project, they

can actively work against it and no matter how well the project is initially designed it will fail.

3.6.1 Naturalness

Ratcliffe (1977) states that those sites that have been least modified by humans are the most valuable. All urban conservation areas will have been influenced by humans at some level and so whether any of these sites have any remaining naturalness is difficult to determine; however, in agreement with Ratcliffe (1977) those sites that are less influenced will be more valuable as habitat to those species threatened by human activities. Those areas that are heavily influenced by human disturbance will be considered as failing this criterion.

Whether or not habitat re-constructions are able to remove years of abuse or add another layer of human influence to an already disturbed environment is a philosophical problem and not an ecological problem. What matters is whether the species that these projects are supposed to help are able to benefit. This might not be able to happen with habitat re-creation projects as habitat re-creations occur on land that has been severely disturbed. Disturbance happens whether or not humans are the cause of it (or the cause of the later re-creation of habitat even); however, disturbances do not favour those species which are under threat and vulnerable to external influences. As previously stated, it is this range of threatened species that urban conservation areas should attempt to protect.

In an ideal world all habitat re-creations would be as good as the original; however, we do not have all the answers yet, and there needs to be the realization that the re-creation may not be as good as the original. Project organizers must understand that restoration projects may not even work (Bradshaw, 1998). Ecosystems are complex, and "failure to reconstruct any part of it properly will cause it to function improperly or fail to function at all" (Bradshaw, 1998). In addition to the possibility of the creating malfunctioning habitat, there is a danger in habitat re-creation in that it undermines the

very concept of urban conservation areas. According to Kendle and Forbes (1997) why should an area be conserved if it can be re-created later or somewhere else?

3.6.2 Typicalness

Urban conservation areas should try to be representative of typical wildlife habitat found in the area (Ratcliffe, 1977). Preservation of only rare or unique sites may not be relevant to many species and value needs to be placed on sites that may be more common. Those projects that attempt to conserve habitat that is typical for the area will be considered to have passed this criterion.

3.6.3 Management and monitoring

As conservation areas are complex systems – urban conservation areas more so because of the added complexity of the urban environment – management and monitoring becomes an essential feature of a successful conservation attempt (Kendle and Forbes, 1997). There are countless factors that influence an urban conservation area and their effects can vary over time. In order to keep making progress towards habitat improvements, there must be management and monitoring in order to attempt to balance the effects of external and internal factors (Kendle and Forbes, 1997). Urban conservation areas cannot be left to evolve on their own, as due to human induced disturbances, they are likely to become degraded (Carr and Lane, 1993; Adams, 1994). Those projects that have management and monitoring will be considered to have passed this criterion.

3.6.4 Involvement

As urban conservation areas are strongly dependent on the cooperation and understanding of the surrounding community, these areas need to be of value to the community. The level of participation by the community in the initial planning, and later, operations and monitoring, can be an important indicator of this value of an urban conservation area to the public (Tait et al, 1988; Carr and Lane, 1993). If the public appreciates and respects a conservation area, they will likely be more willing to respect the goals and objectives of the site, allowing an urban conservation area to achieve a goal

of improved wildlife habitat (Tait et al, 1988; Carr and Lane, 1993). Those projects that involve the surrounding community in their design and/or management will be considered to have passed this criterion.

3.6.5 Recorded history

In agreement with Ratcliffe (1977), those areas that have a longer recorded history are more valuable due improvements in management that can be made because of years of data, as well as to their potential ability to contribute to academia. Areas that have a detailed, but shorter history, are also valuable for the same reason.

In addition to community involvement, there should be some level of involvement by specialized professionals and/or academics (Kendle and Forbes, 1992). Even in those urban conservation areas that eventually fail, there is value in the attempt if the attempt is properly documented (Kendle and Forbes, 1992). A well-studied failure can help future projects come closer to the mark to achieving improved wildlife habitat. Those projects that have been previously well studied or are currently well studied, will be considered to have passed this criterion.

3.7 Effectiveness of Daylighting Projects as Urban Conservation

Creek daylighting projects are currently underway or completed for a variety of reasons that have been discussed previously. Sometimes the primary motivator is habitat restoration or re-creation, but often, it is not. Instead, improvements in wildlife habitat are marketed as a secondary or tertiary benefit of some other objective that the daylighting project will primarily address. There is a danger in depicting daylighting projects as effective contributions to urban conservation as if they are not able to do this, they are taking money and effort away from other conservation efforts; however, for those people currently considering creek daylighting it may be possible to borrow design aspects from projects that are successful in providing habitat for urban wildlife and therefore make the project an effective contribution to urban conservation.

By using the eight criteria stated above it will be possible to assess the potential value of creek daylighting for urban conservation. As previously stated, these are coarse filter criteria designed in order to assign relative value to conservation areas for a range of wildlife species. The concept of creek daylighting, illustrated by eleven specific project examples, will be compared with each criterion from which overall conclusions can be drawn (Table 3-1). It is recognized that this is not a comprehensive examination of every daylighting project, and that there are other projects that could have been included. Although this is true, the chosen examples are a cross section of North American daylighting projects having a range of sizes, budgets and primary objectives. Taken together, they may be able to show if overall, past and proposed creek daylighting projects can be considered effective conservation attempts.

After scoring each project on whether or not they pass specific criteria, an overall assessment for the conservation project will be given. Those projects that do not pass all three of the criteria deemed to be essential aspects of effective conservation (Structural Diversity, Buffers, and Connectivity) would be classified as projects that are likely to be ineffective as conservation areas. Partial scores would be given to those projects that include all three aspects essential to effective conservation, but do not pass on other criteria. Those projects that are classified as effective conservation are those projects that pass on all eight criteria. A summary of evaluation results is listed in Table 3-1.

Table 3-2: Summary of daylighting project evaluations. Those projects that did not pass all of the essential criteria of Structural Diversity, Buffers, and Connectivity were deemed ineffective attempts at conservation. Partial scores were given to those projects that passed these three criteria but failed others. An effective score would have been given to a project that passed all eight criteria.

Project	Location	Criteria								Summary
		Structural Diversity	Buffers	Connectivity	Typicalness	Naturalness	Management	Involvement	Recorded History	
Arcadia Creek	Kalamazoo, MI	no	no	no	yes	no	yes	yes	no	ineffective
Cow Creek	Hutchinson, KS	no	no	no	yes	no	yes	yes	no	ineffective
Darbee Creek	Roscoe, NY	yes	no	yes	yes	no	yes	yes	yes	ineffective
Hastings Creek	Vancouver, BC	yes	no	no	yes	no	yes	yes	no	ineffective
Jolly Giant Creek	Arcata, CA	yes	no	no	yes	no	yes	yes	yes	ineffective
Phalen Creek	St. Paul, MN	yes	no	no	yes	no	yes	yes	no	ineffective
Spanish Banks Creek	Vancouver, BC	yes	yes[2]	yes	yes	no	yes	yes	no	partially effective
Strawberry Creek	Berkeley, CA	yes	no	no	yes	no	yes	yes	no	ineffective
Taddle Creek	Toronto, ON	n/a	no	no	yes	no	n/a	yes	no	ineffective
Thain Creek	North Vancouver, BC	yes	no	no	yes	no	yes	yes	no	ineffective
Valley Creek	Port Angeles, WA	yes	no	no	yes	no	yes	yes	no	ineffective

(Brown et al, 1996; Vancouver Park Board, 1996; City of Kalamazoo, 1997; University of Toronto, 1997; Botelho, 1999; City of Vancouver, 1999b; Pederson, 1999; Wolfe Mason, 1999; City of Port Angeles, 2000; Miller, 2000; Mosquito Creek Stewardship Society, 2000; Pinkham, 2000)

[2] Size of individual project not sufficient, but surrounding natural area compensates

3.7.1 Structural diversity

Including structural diversity as part of the project's design would be a way to increase the ability of the urban conservation area to protect wildlife. In a natural stream, habitat for a variety of species would be provided by such things as fallen logs, gravelled bottoms, shaded pools, or stretches of rapids (Barnes and Mann, 1991). A structurally diverse daylighting project would include feature such as these as part of the project's design.

A study of eleven creek daylighting projects from around North America reveals that there have been numerous visions of what a daylighted creek would look like. Proposed projects, such as the proposed extension to the existing daylighted section of Strawberry Creek in Berkeley, California (Wolfe Mason Associates, 1999; Pinkham, 2000) or Taddle Creek in Toronto, Ontario (University of Toronto, 1999) show that there is a multitude of options even for the same creek. From this range of options, if one of the goals is to truly provide improvements for wildlife habitat, an option must be chosen which reflects that.

Several projects, such as Jolly Giant Creek, in Arcata, California (Ekman and Murphy, 2000; Pinkham, 2000) or Spanish Banks Creek in Vancouver, British Columbia (City of Vancouver, 1999b) include provisions for both riparian and terrestrial wildlife while other projects appear to be designed for aesthetic improvements or structural purposes only. Creeks such as Arcadia Creek in Kalamazoo, Michigan or Cow Creek in Hutchinson, Kansas run in concrete canals (City of Kalamazoo, 1997; Pinkham, 2000) with little attempt to include wildlife habitat. Up until 1998, the water source for Phalen Creek, in St. Paul, Minnesota was even treated with considerable amounts of biocide (Pinkham, 2000).

There is little consensus on structural diversity as part of project design - some projects include a diverse range of potential habitats, and some do not. The projects that do include structural diversity are listed as 'naturalization' projects or 'no-constraints' projects in table 1-1. For those that do not, they cannot be considered as providing

habitat for threatened species of urban wildlife (listed as canalization or symbolic in table 1-1).

3.7.2 Buffers

When examining the eleven daylighting projects, no project design influenced a large enough area to be an effective attempt at urban conservation as no design included a buffer strip at least 30 m wide. However, smartly placed projects can be buffered because of their immediate surroundings (Table 3-2). The daylighting project at Spanish Banks Creek is such an example. The project is located within a large urban natural area, and so the park provides an effective buffer from urban developments. In fact, as the motivation for this project was habitat improvement, it was the relatively undeveloped watershed of Spanish Banks Creek that made decision makers select it as a daylighting project in the first place (Page, pers. comm.).

If a fine filtered approach to conservation, geared to the requirements of a specific species, had been employed it may be possible to modify the buffer requirements for that particular species. As the criteria were designed in order to assign relative value to conservation areas for a range of urban wildlife this was not possible. Depending on a species' needs and the influences that they are subject to, the buffer required could be much more or much less, and may even depend on the type of buffer utilized. Using a standard measurement of 30 m of land as the buffer required to protect threatened species from external disturbances, few projects passed this criterion (Table 3-2).

Table 3-3: Table showing approximate length and amount of green space immediately surrounding a given project. Required area is calculated by extending a buffer zone of 30 m per side perpendicularly from the center of a daylighted creek.

Project	Length (m)	Approximate area (Ha)	Required buffer area (Ha)	Size/Shape Criterion Result
Arcadia Creek	472.4	0.8	28.3	FAIL
Cow Creek	243.8	2.0	14.6	FAIL
Darbee Creek	100	0.4	6.0	FAIL
Hastings Creek	800	32	48	FAIL
Jolly Giant Creek	49	2.4	2.9	FAIL
Phalen Creek	640	17	38.4	FAIL
Spanish Banks Creek	58	9.3	3.5	PASS
Strawberry Creek	61	1.6	3.7	FAIL
Taddle Creek	100	0.04	6	FAIL
Thain Creek	200	0.3	12	FAIL
Valley Creek	149.4	1.1	9.0	FAIL

Urban conservation areas should help in some way to halt the decline of those species that are negatively affected by human activities, and so by this definition, without substantial buffers to produce core habitat at the centre, creek daylighting projects can do little to protect those species that need protection. Creek daylighting projects may be able to provide refuges for urban wildlife species that are not easily disturbed by human disturbances, but will not truly serve their purpose as urban *conservation* areas.

Not all of the eleven daylighting projects surveyed were large enough to include buffers in order to be effective for urban conservation. Most of the projects are less than a block in length, and are located within landscaped open spaces largely lacking in natural vegetation. Either a single large-scale attempt or a coordinated series of smaller attempts would be more effective at urban conservation. The exception is Spanish Banks Creek in Vancouver, British Columbia. Although the project is not very large, it is well located within a large urban natural area.

3.7.3 Connectivity

Most of the eleven daylighting projects examined do not connect waterways and therefore do not allow free movement of wildlife for those species dependent on waterways (Table 1-1). Many of the surveyed daylighting projects bring to the surface only a segment of a buried waterway – perhaps a block or two in the case of Strawberry Creek (Wolfe Mason, 1999), or many blocks in the case of Arcadia Creek (Pinkham, 2000). For a brief period, the creek is exposed to the surface, and then is returned to a culvert. Except for this segment of the creek, the rest of the creek remains below ground. The only wildlife which would likely be able to make the journey to the daylighted section are likely those that are not under threat and are not disturbed by human activities in the first place (Kendle and Forbes, 1997).

Of the eleven projects examined, there are some that do recognize the importance of connectivity. Spanish Banks Creek in Vancouver, British Columbia is an example of such a project (City of Vancouver, 1999b; Miller 2000). The majority of the watershed was undeveloped except for a segment near where Spanish Banks Creek empties into Burrard Inlet. By daylighting this section it became possible for salmon to gain access to spawning grounds further upstream (Miller, 2000).

Although currently not connected, daylighting projects that do not have connections to other waterways or green spaces may become connected in the future. Several of the projects examined, such as Jolly Giant Creek or Strawberry Creek, have excited the community to the point where other projects are now in the works to daylight more segments (Pinkham, 2000). Many small projects connected over larger areas that allow freedom of movement for species could be an effective form of urban conservation. A very small creek daylighted through the residential lots of a subdivision in order to join up with a nearby watercourse would pass this criterion. The eleven daylighting projects were evaluated as to what has been implemented or proposed in an existing plan. Future desires to possibly daylight further sections were not included in the evaluations. As such, few of the projects surveyed pass this criterion.

3.7.4 Naturalness

As every daylighting project is a habitat re-creation, the eleven projects surveyed fail the criterion of natural-ness according to its previously stated definition. For these projects, an attempt was made to create habitat out of nothing, yet, as with all habitat re-creations, there is a fear that something of ecological importance may have been left out. These new open spaces will undoubtedly provide habitat for urban wildlife species. What is not so certain is whether they will fulfill the previously stated purpose of conservation – to provide protection for threatened species of urban wildlife – as effectively as a project that had less disturbed habitat in the first place. A decision maker must take this into account when deciding among the range of options for conservation that could occur, as a creek daylighting might work, however, it might need much more time and effort in order to become an effective attempt at urban conservation than a project that takes place in a less disturbed area.

3.7.5 Typicalness

The eleven creek daylighting projects examined are effective in this criterion in that when taken into a city-wide perspective, they widen the range of habitats that are protected by including more riparian habitats. Riparian areas are (or were) a common feature of all the urban settlements in which the eleven daylighting projects are found. These eleven projects are not preserving or re-creating something which was rare or unique, and should therefore, be of benefit to a wide-range of wildlife species.

3.7.6 Management and monitoring

A substantial number of the eleven projects examined are managed by the respective parks department of the municipality; however, some are not managed as well as others (Pinkham, 2000). According to Wolfe Mason (1999) and Pinkham (2000) some of the initial budget must be allotted to allow for a return to the daylighting project after a year has past to review and rethink what has happened. As all the projects surveyed included some measure of management and monitoring, they all pass on this criterion.

3.7.7 Involvement

Fortunately for the eleven daylighting projects investigated, their respective communities came together to support the attempt. Community organizations rallied behind the idea of improving property values, or more altruistically believing that creek daylighting projects could be beneficial to urban wildlife. It can be concluded that the eleven daylighting projects looked at are valuable to the community based on the level of involvement. By being valuable to the community in this respect, there is a greater likelihood that the daylighting project will receive the political support necessary to continue to provide wildlife habitat to threatened species.

3.7.8 Recorded history

The eleven creek daylighting projects surveyed have only the briefest of histories. Even if records were kept before the creek was buried, the reconstructed habitat may not bear any resemblance to the original (Kendle and Forbes, 1997). As such, the daylighting projects examined fail the criterion of having a recorded history. Although it will not be possible to substitute for years of records, detailed and reliable observations begun since the creek was daylighted can make the project useful from a point of conservation studies. Two daylighting projects have such studies currently underway (Jolly Giant Creek and Darbee Creek) and so pass this criterion. The other nine projects do not.

3.8 Summary

The above discussion generated a list of criteria that can be applied to all urban conservation projects in order to develop a sense of relative value as habitat for those species of urban wildlife that are in decline. By distinguishing among various ways of performing urban conservation, it becomes possible for planners to decide where to allocate limited resources. The results of the evaluation suggests some projects proposing that improvements in wildlife habitat will occur as a secondary benefit when a creek is daylighted will not realize these expected benefits. In fact, the opposite results could occur as these projects may lead to the creation of 'sink' habitats.

Conservation biologists refer to two categories of habitat based on their characteristics (Meffe and Carroll, 1994). One category is referred to as source habitats. In these types of habitat, conditions are favourable, and so wildlife populations grow and disperse to other areas. The other category is called sink habitats. Here conditions are not good, and the population is in constant threat of disappearing. The only thing that keeps sink populations from extinction is migration from source habitats (Meffe and Carrol, 1994).

Some daylighting projects could be seen as sink habitat. The right conditions for survival of a species may not be present. This could be caused by many things, such as insufficient buffers, or lack of a reliable base flow (Pinkham, 2000). Lack of reliable base flow could be caused by a variety of reasons; but regardless, the lack of a reliable source of clean water is detrimental to any aquatic community (Barnes and Mann, 1991). At times, the urban waterways may have too much water moving at too great a pace or too little water to flow at all. Although sink habitats are not limited to daylighting projects, project designers must be wary that a project funded to benefit wildlife is not in fact creating sink habitat.

According to the defined evaluation criteria, a creek daylighting project similar to the eleven surveyed, is by itself, not an effective tool for planners to use when attempting to conserve threatened populations of urban wildlife. When evaluated according to the components of an effective urban conservation area, almost all of the eleven creek daylighting projects surveyed fail on the essential criteria of sufficient buffers, and connectivity, as well as fail the less essential criteria of naturalness and recorded history. Some of the projects examined fail on other grounds as well. These are important criteria for the long-term duration of a range of wildlife species in a given area; however, these criteria are derived from using a coarse filter approach and some modification may be needed if one is concerned about a particular wildlife species.

Given the low value as urban conservation of the eleven creek daylighting surveyed, it is suggested that creek daylighting projects similar to the ones surveyed, not

be pursued as a means to improve wildlife habitat for a wide range of threatened species of urban wildlife. According to Kendle and Forbes (1997) restoration projects, such as creek daylighting, may "divert priorities and resources away from other areas and should only be undertaken where there is a clear recognition of their purpose and value." Zedler (1998) adds, "preventing the plague of excessive habitat loss is preferable to the lengthy, costly, and uncertain cure of restoration."

By marketing daylighting projects similar to the ones examined as the means to improve wildlife habitat there is a fear that this will draw limited funds away from more effective conservation projects. This is not to say that creek daylighting projects should not be done. There are many benefits to bringing buried streams back to the surface as discussed previously; however, they should not be carried out in a manner similar to the ones examined, as they are unlikely to conserve a wide range of threatened wildlife species in the urban environment. As will be discussed in the next section, by including conservation objectives as part of the design, or using daylighting projects as part of a larger conservation effort, there may be a role for creek daylighting as a means of performing urban conservation.

CHAPTER 4

Conclusions and Recommendations

4.1 Discussion of Results

The results as indicated from the evaluation of eleven creek daylighting projects as urban conservation could be interpreted as there being little reason to pursue daylighting as a way of providing habitat for urban wildlife. For creek daylighting projects similar to the eleven evaluated, this holds true, as many of these may not be effective urban conservation attempts according to the general criteria used to evaluate urban conservation areas. However, this raises two points:

1) The criteria used were general criteria based on a coarse filter approach in order to estimate the approximate value of a project as quality habitat for a wide range of threatened urban wildlife species. Using such a general set of criteria may not give a clear picture of the needs of a particular species of urban wildlife in a particular urban setting.
2) Daylighting projects that choose to try to provide wildlife habitat can learn from past projects and use the evaluation criteria as a set of design principles.

A coarse filter approach to assigning relative value to conservation areas uses general criteria in order to determine habitat quality for a range of species. Individual species' needs are not addressed. If a conservation attempt was proposed in order to provide habitat for a particular species of wildlife, the criteria in this report may not be adequate. For example, a buffer of thirty metres may be excessive in order to protect some species from some disturbances, yet it may not be enough for other species. In addition, the criteria of connectivity only evaluated the connectivity of waterways. Admittedly, a break in open water may be an overwhelming obstacle for some species, yet it may be less than an inconvenience to other species. In addition, the less essential 'human factor' criteria only indirectly measure habitat quality by postulating that the actions of people directly affect habitat quality. For instance, a recorded history may be

very important for people to manage an urban conservation area in order for it to sustain quality habitat, yet managers may be able to achieve sustainable quality habitat even without years of historical data. If a project's goal is a more fine filtered approach designed for one species only, then project designers must realize that some modification of the criteria as presented in this discussion is needed.

Another issue with the method of evaluation used in this report is that the chosen criteria come from a still evolving body of literature. Although these criteria are commonly cited in conservation studies, they do not capture all of the complexities that exist in the natural world (Smith and Theberge, 1986), and so the criteria as presented may be too stringent or too lax depending on the particular species and the particular situation. By evaluating urban conservation areas by their attempt to provide habitat for a variety of threatened species of urban wildlife, they do not distinguish between those species that need some protection and those species that need more. For example, some threatened species of urban wildlife may thrive in areas that receive 'partially effective' ratings in this discussion, as they do not require as much protection as anticipated or are able to adapt to disturbed habitats in ways not taken into account. As stated previously, a fine filter approach to conservation may compensate for this.

The criteria as used may also not account for discrepancies in the information available in project plans and descriptions. Project reporters may have felt that certain aspects of the project were not needed in project plans and were therefore left out. The method as employed in this discussion attempted to determine as much as possible about each project evaluated, however, it is possible that some projects were unfairly criticized for not including particular design aspects not because they are not present in the project, but rather, because they have never been recorded in the literature.

Even though these are general criteria with the above stated problems, they are still of use. They can be used as stated earlier in this report to assign and compare relative value to a variety of different approaches to providing wildlife habitat in urban

areas. Planners and decision makers can then use these qualitative conclusions to make tough decisions on how to allocate limited resources. The criteria can also be used as design principles. If included from the beginning as part of a project, or later as modifications to existing projects, the inclusion of design aspects that acknowledge the important principles behind the evaluation criteria can ensure that daylighting projects are effective at providing wildlife habitat to a wide range of urban wildlife species.

For example, Spanish Banks Creek in Vancouver B.C., designed from the start as a means to improve habitat, included many of the criteria that were used to evaluate creek daylighting projects. Other projects can learn from this example in that this project was done relatively cheaply and yet was able to include design aspects that would indicate that it would provide wildlife habitat. Future daylighting projects may be able to follow its example, and current projects may be able to use it to make modifications in order to improve a project's ability to provide wildlife habitat. By daylighting this one section of Spanish Banks Creek, project organizers were able to open up an entire watershed of viable habitat. In addition, the location of the project within a large park suggests that the required 30 m buffer zone around the project is not necessary, as the park itself would serve as the buffer. The only reason why this project failed to be considered as completely effective urban conservation is that it did not pass the criteria of naturalness and recorded history.

As stated in this report, naturalness is a general criteria meant to be used when evaluating many projects according to a coarse filter approach. A wider range of threatened species will find that the less disturbance a habitat experiences, the more beneficial that area will be to them (Meffe and Carrol, 1994); however, certain species, even threatened species, may find that a habitat re-creation does not leave out elements that are important to their survival. In this case, the habitat may be adequate for that species. For Spanish Banks Creek, a project mainly designed to improve salmon access to upstream areas, the project may be completely successful. A coarse filter approach where general criteria are used in order to evaluate conservation areas on their abilities to

provide habitat to a range of species would not be able to capture this, while a fine filtered approach where the project was evaluated specifically for its ability to provide habitat for salmon may be able to do just that.

4.2 Recommendations

Creek daylighting, as illustrated by the eleven examples surveyed, may not be an effective tool for providing quality habitat to a wide range of urban wildlife species, yet it is being performed and at some considerable expense. When considering spending money on urban conservation, planners need to carefully consider their options. As discussed in the previous chapter, not all conservation attempts are equal, and there are ways to qualitatively distinguish among them. A suggested 'hierarchy of conservation' can be used by planners when dividing resources among competing conservation efforts:

1) Protection and preservation of habitat in existing areas
2) Restoration of habitat in degraded areas
3) Re-creation of habitat in areas where it no longer exists

If a city is so unfortunate as to no longer have the option of protecting existing habitat, then it should focus efforts on restoring degraded areas. If that task can be accomplished, then efforts can be made to re-create habitat. As daylighting projects fall under the latter category, creek daylighting as a tool for urban conservation should be carefully considered. However, urban waterways are important and are in need of some protection.

After acknowledging that riparian habitat and natural areas in general are important to the urban environment, planners should propose urban conservation attempts that are designed to fulfill the eight criteria of effective urban conservation discussed previously. The ideal conservation area would be a large one with a variety of habitat types, connected to other such areas. It would also involve the academic and surrounding community in managing and monitoring the site in an environmentally sustainable

management and monitoring manner. It is recognized that this might not all be possible in one place. Therefore, planners should focus on connecting a network of protected areas, with a framework based on riparian corridors. These corridors would link natural areas and open spaces that already play differing roles in the community.

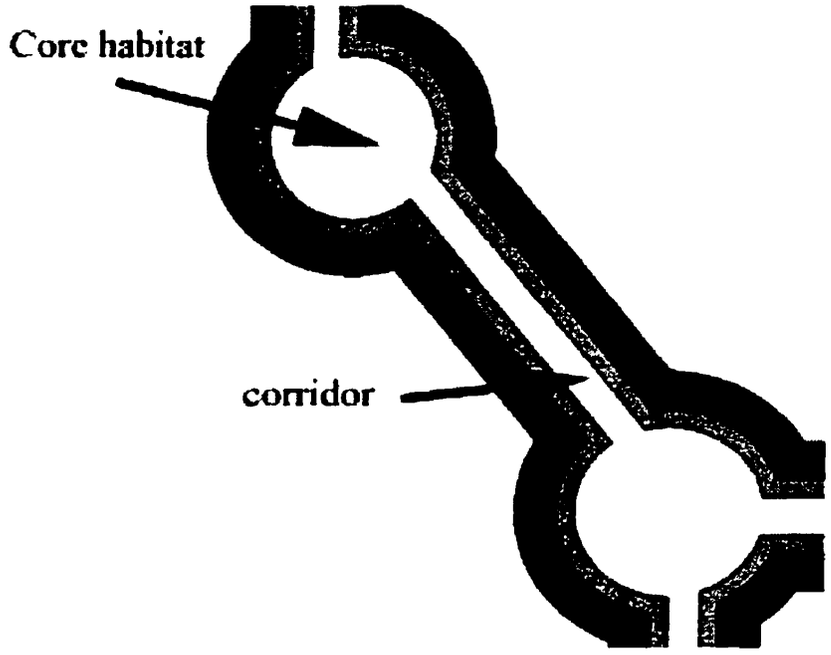

Figure 4-1: Figure illustrating how a network of core habitat can be surrounded by increasing levels of development.

As proposed by Noss (1992), multiple-use modules (MUMs) networked together would provide both the size and mobility necessary to include a variety of habitats as well as the freedom of movement necessary for the long-term survival of wildlife. There is no reason to believe that this would not work for urban areas. Within this network would be zones of increasing activity and development as distance from a core protected area increases. In an urban area, the core area should be composed of existing habitat that has escaped development. This would allow for residential, commercial and even industrial uses to occur, while still providing habitat for wildlife. Establishing this network would need to be a long-term strategy as pieces of the puzzle may not be

available for conservation purposes right away. Over time, a network can be established through conservation easements or direct purchase.

Riparian corridors within a protected area network are suggested as the base for this system as wildlife frequently travels along them (Riley, 1998). Within a city, these corridors will often be fragmented; however, focused long-term efforts can link these fragments through daylighting and restoration of surrounding areas. In this context, daylighting can serve a purpose as it is not the end product, but only a tool to achieve an end. The daylighting project is not the location of the wildlife habitat, but rather, a connection between wildlife habitats. Each new daylighting project will forge a new connection within the network and to other areas outside the city. Cities in Europe have successfully utilized this technique of multiple use protection.

Known as Green Fingers in Copenhagen, Denmark, wide ribbons of habitat poke into central parts of the city joining green spaces within the city to areas outside (Beatley, 2000). A system similar to this but based on riparian corridors would need to daylight creeks in order to create a complete network. As daylighting can be expensive, municipalities should be willing to try different tactics in order to achieve a complete network of riparian habitat.

Firstly, a city needs to protect existing riparian habitat. New projects should not be permitted in floodplains, and sufficient buffers need to be enforced so that new developments do not impact upon riparian systems. Specialized zoning can be implemented if necessary to eliminate inappropriate developments (Scueler, 1995). Secondly, developers should be educated of the benefits of voluntarily daylighting streams on their properties, or encouraged to participate either through tax incentives or development agreements in order to add to a protected areas network. Thirdly, municipalities must combat storm water management at the source. By limiting impervious areas, and allowing for increased drainage into the soil, a city can both improve water quality, reduce the frequency of flooding as well as recharge ground water

stores, which in turn can help to facilitate sufficient stream base flows of clean water. During construction, developers must be conscious of the large amount of sediment that can be eroded from a construction site before a development is finished, and so install compensating measures to minimize erosion (Schaefer, 1996). Daylighting projects carried out by public agencies on public properties are just one tool in a toolbox of many tools – all of which need to be considered and used in order to adequately protect urban natural areas.

An envisioned network of riparian habitat that utilizes daylighting as a means towards completion could be based on ideas prominent in the design of the Garrison Creek project and the daylighting project that took place on Spanish Banks Creek. The Garrison Creek proposal stresses the importance of waterways to the surrounding community. It tries to reclaim a role for urban watercourses as both a way of improving storm water management, as well a means to link isolated open spaces together. Combined with the approach taken at Spanish Banks where wildlife habitat and wildlife access were the driving forces behind the project, a hybrid system such as this would be able to serve the surrounding community and provide wildlife habitat. MUMs as proposed by Noss (1992) would be part of the system as well, allowing commercial, residential, industrial and conservation areas to co-exist and co-evolve.

Without including creek daylighting projects in a larger context, they are doomed to be ineffective attempts at conservation. As shown in the previous section, daylighting fails the majority of the eight criteria that are important for effective urban conservation. In addition, as daylighting is the re-creation of habitat there is a danger in pursuing it without including it in a broader context. Habitat re-creation projects raise the question of "why conserve habitat if we can just re-create it later?" However, a facsimile is never as good as the original, and a re-creation may leave out vital components. The more complex the original, the more likely that components will be left out. As ecosystems are extremely complex and we have only begun to understand how they function, it is naïve to believe that a re-created ecosystem could exactly replace an original.

The argument that states that people should attempt to fix what we have broken has merit; however, in a world of limited resources, difficult decisions must be made. While there is still a choice that can be made – to utilize resources for conserving existing habitat, or to re-create habitat out of nothing – the choice is clear. Resources must be used to conserve and ameliorate what is already in place. Anything else mocks the foundation of conservation – that life has value itself, regardless of our understanding of it, or a conceived use for it. If habitat can be re-created at any time, there is little point in expending resources to protect existing habitat (Kendle and Forbes, 1997).

This is a fundamental problem for the long term viability of wildlife habitat for those creek daylighting projects proposed for purely utilitarian reasons. The concept is heralded as a profound change in planning cities. In fact, it is not. Creeks were buried because they were perceived as having no use to the city. Buried creeks are being daylighted largely because cities have found a new use for them, for aesthetic improvements, for storm water management, etc. There is no sign of a greater appreciation of the intrinsic value of the creeks, that the riparian ecosystem and the life within has value unto itself, but rather that municipalities have found a new instrumental value for urban creeks.

Ethicists have shown that the appreciation of something does not last for the long-term when the object is valued for its instrumental value alone. Once that instrumental value is lost, or something with greater instrumental value is discovered, the worth of the object itself is lost, and it is no longer appreciated. However, if something is seen to have intrinsic value, then it does not matter what the instrumental value of the object is, it will always be of worth (Meff and Carrol, 1994). The majority of creek daylighting projects reviewed did not show evidence of valuing the creeks for intrinsic reasons. The creeks were daylighted for some other reason, not simply because they were buried.

To expend money and resources on these projects in the name of conservation when they are not intrinsically valued (nor likely a functional copy of the original) does not bode well for wildlife populations that make a daylighting project their home as attitudes can change, and creeks can be re-buried. There is hope, however, that those areas that come to accept creek daylighting projects into their communities will begin to intrinsically value a creek that was daylighted for purely instrumental reasons. If every child grew up in such a neighbourhood, then perhaps there will be no need to discuss creek daylighting, as all buried creeks will once again flow in the sunlight, and no creek will ever be lost again.

APPENDIX 1

A.1 Example Projects

Several daylighting projects were chosen as illustrative examples in order to evaluate the concept of creek daylighting as urban conservation. These projects were chosen because they represent a cross-section of current projects in North America - having a range of size and budgets, diverse objectives and varying designs. Descriptions of the projects are listed in alphabetical order, and this information is summarized in Table 3-1. For each project description, information is given on structure of the area surrounding the project, a brief history of the watershed, design of the project, who was involved, and what resulted. This information was used in order to evaluate the effectiveness of creek daylighting projects as a tool for urban conservation. Although attempts were made to be as thorough as possible, discrepancies in information may still exist. Projects that are considered as lacking in certain aspects may only be so on paper, as they may actually contain such aspects, but they were not included by project plans or descriptions.

A.1.1 Arcadia Creek – Kalamazoo, Michigan

Location

Arcadia Creek is located in the downtown area of Kalamazoo, Michigan. The City of Kalamazoo has a core population of 80 000 people; however it is the centre of a total population of approximately 250 000 people in south western Michigan. The Arcadia Creek watershed is mostly urban (Pinkham, 2000).

History

Arcadia Creek has been underground for the better part of 100 years. As impervious areas increased, so did the frequency of flooding as the culvert that contained Arcadia Creek was not large enough to handle the increased runoff (City of Kalamazoo, 1997). City engineers examined the cost of replacing the culvert but discovered that daylighting the creek and placing it in a canal would be cheaper. Construction of the project took place between 1989 and 1992 (Pinkham, 2000).

Design

This project was part of a major downtown redevelopment campaign that included five blocks of a daylighted Arcadia Creek. Three of those blocks are concrete walled, while the remaining length is a storm water pond with landscaped, grassy slopes and re-creation areas. A concrete channel was used, as the groundwater levels in Kalamazoo are now too low for a creek to exist at the surface. It was not in the budget to create a riparian corridor or more naturalized creek. The total cost of the project was $18 million US, $7.5 million US specifically for daylighting Arcadia Creek (Pinkham, 2000).

Involvement

The project was done largely with the involvement of consultants and the City of Kalamazoo. Private donations helped with acquiring some properties (Pinkham, 2000).

Results

Previously subject to frequent flooding, city engineers predict that Kalamazoo is now protected from anything up to a 500-year flood. The new festival site has an annual associated revenue of $12 million US, and property tax revenues near the creek have risen from $60 000 US to $400 000 US annually (Pinkham, 2000).

A.1.2 Cow Creek – Hutchinson, Kansas

Location

Cow Creek is located in the downtown area of Hutchinson, Kansas. Prior to daylighting, the creek ran length-wise underneath a major downtown thoroughfare (Pinkham, 2000).

History

The section of highway that Cow Creek ran under needed to be rebuilt. Instead of rebuilding the road exactly as it was (with Cow Creek running in parallel underneath the road for a considerable distance) city officials decided to re-route Cow Creek so that the road crossed the creek (Pinkham, 2000).

Design

After crossing underneath the rebuilt road, Cow Creek flows at the surface for approximately 244 m in a curved concrete channel in a new park. The city did not believe that a more natural channel would be appropriate for the downtown. The new park, completed in 1997, includes other outdoor amenities such as a streamside path, and a grassy amphitheatre. Total cost for the park was $4 million US, $1.25 million US of which was for the daylighting project (Pinkham, 2000).

Involvement

This project involved the city and its consultants, along with state and federal representatives (Pinkham, 2000).

Results

The park is considered a valuable new amenity for the downtown (Pinkham, 2000).

A.1.3 Darbee Brook – Roscoe, New York

Location

The project is located on the grounds of Roscoe Central School in Roscoe New York. The surrounding area is largely residential with some agricultural (Pinkham, 2000).

History

The last section of Darbee Brook was buried in 1960 when the school received permission to expand its playing fields. The culvert in which Darbee Brook was buried emptied several feet above its receiving waters, physically preventing fish from traveling upstream. Since installation, the culvert has subsided, causing damage to the school's playing fields. Inclement weather in the mid-1990s caused further damage and warranted that something be done (Pinkham, 2000).

Design

The culvert was replaced with fill, and Darbee Brook was re-located to a new 101 metre channel. There was not sufficient room to allow Darbee Brook to have a sufficient flood plain because of size constraints. Native plants were used to re-vegetate the banks (Pinkham, 2000).

Involvement

The project involved Roscoe Central School, Trout Unlimited, state and federal representatives, as well as community groups. The volunteer groups maintain and monitor the project (Pinkham, 2000).

Results

The creek has been integrated into the curriculum of several grades. Some classes use Darbee Brook as an outdoor laboratory, while others participate in raising fish as part of the "Trout in the Classroom" program (Pinkham, 2000).

A.1.4 Garrison Creek – Toronto, Ontario

Location

Garrison Creek used to flow from north of St. Clair Avenue, south through Christie Pits and Trinity Bellwoods Park to Fort York on the west side of Toronto, Ontario (City of Toronto, 1998). The area is now completely built up with a combination of residential, commercial and industrial uses. There are several green spaces of considerable size in the area; however, they are not linked in any fashion.

History

Garrison Creek was seen as a source of secure water and has been listed as one of the reasons for the placement of Fort York in the late 1700s (Brown et al, 1996). Eventually, many industries would be established along the shores of Garrison Creek and they would use the creek for both water source and dumping ground. By the late 1880s, along with other creeks in Toronto that had become perceived as open sewers, Garrison Creek was buried in a 10 foot diameter brick combined sewer (Brown et al, 1996).

Interest in the idea of daylighting Garrison Creek stems from an idea by Brown et al (1996) to use the creek as a means of both storm water management and a way to connect the city back with its natural environment.

Design

Proposed initially as a 'co-evolving' system illustrating the connections between the built environment and its surroundings, the Garrison Creek Linkage plan would connect a series of existing greenspaces around the importance of water to the urban environment (Brown et al, 1996). Brown et al's (1996) plan is based in part on similar concepts thought to be behind the Trevi Fountain in Rome. A common tourist attraction, the fountain is both a work of art and the end of an aqueduct, showcasing the importance of water in the urban environment (Brown et al, 1996). By linking storm water ponds in parks along the former Garrison Creek channel, along with improvements to the parks themselves, Brown et al (1996) hoped to develop a model for other urban areas showing that the urban environment and its surroundings can and should be managed as a whole unit. More recently, the City of Toronto has taken this idea and modified it so that green spaces in the Garrison Creek area would be more conceptually, rather than physically, linked by the idea of the important role of water in urban areas (City of Toronto, 1996; Pederson, 1999).

Involvement

The project is currently in the hands of the City of Toronto which is working with community groups to evaluate suitable developments to occur in and around the open space system (Pederson, 1999). There is currently little involvement by Brown and Storey architects (pers. comm.).

Results

The project envisioned by Brown et al (1996), has been modified to such a degree by the City of Toronto (City of Toronto, 1996; Pederson, 1999) that it is not likely to resemble the original vision of a daylighted Garrison Creek. The idea as currently proposed by the City of Toronto is to use the former channel of Garrison Creek as a way

to develop an open space system, without using a daylighted Garrison Creek as a physical link to join them. As such, this project will not be included in the evaluation of creek daylighting projects as effective urban conservation. This description of the project was included because Garrison Creek Linkage Project is a good example of a project that strives to make connections between human and nature and as such, is discussed in later sections.

A.1.5 Hastings Creek – Vancouver, British Columbia

Location

Hastings Creek used to flow on the City of Vancouver's East Side, near the current Hastings Park (better known as the Pacific National Exhibition (PNE) grounds). The creek no longer exists as the volume of water that made up its flow has been diverted into storm sewers. The watershed is mostly developed, and a residential area makes up the majority of the catchment area (Bothello, 1999).

History

Hastings Park was granted in trust to the City of Vancouver in 1889 by the province to become "a constant resort for all lovers of romantic woodland scenery and lovely groves" as stated by former Mayor David Oppenheimer over a hundred years ago (Vancouver Park Board, 1996). Since that time the park has focused on entertainment, as it was the location for horse racing, professional sports, conventions, and trade show, concerts and an amusement park. During this time, the park lost its greenery as well as its waterways – a stream had existed in the park until 1935. In the 1980s, the surrounding community began lobbying the municipality to uphold the park's original mandate. After the PNE's lease expired in 1994, community groups came together to focus on the renewal of Hastings Park (Vancouver Park Board, 1996). The Vancouver Canucks and BC Lions no longer use the area and the PNE is in the process of relocation, so the lands that they occupied are to be redeveloped. Plans for the park focus on a proposed project to daylight Hastings Creek and the park will be dedicated to the area's natural and cultural history (Bothello, 1999).

Design

This is a multi-year project where the City of Vancouver will test the feasibility of daylighting as an alternative method of separating combined sewers. Storm water from the surrounding residential area, as well as storm and ground water from the park itself, will be directed to Hastings Creek. The plans include the creation of several ponds, a freshwater marsh, as well as pools and riffles (Vancouver Parks Board, 1996).

Involvement

A working committee composed of representatives from the community, government and businesses worked throughout 1995 and 1996 on a design for the park. Public consultation will continue during the implementation process. Various community groups are involved with the project, but it will be funded jointly by the City of Vancouver and the Pacific Racing Association (Vancouver Parks Board, 1996).

Results

A portion of the daylighting project has been completed, involving a series of ponds at one end of Hastings Park. As sewer separation is not yet complete, there is a need to supplement storm water and ground water sources with municipal water. This is a multi-year project that will be completed sometime in the coming decades. Estimated cost for the project is $10-12 million to daylight Hastings Creek, $45 million for the entire park project (Bothello, 1999).

A.1.6 Jolly Giant Creek – Arcata, California

Location

Jolly Giant Creek previously flowed through downtown Arcata but was re-routed using a system of canal, culverts and sewers. The watershed is highly urbanized (Ekman and Murphy, 2000).

History

Much of the length of Jolly Giant Creek has been culverted or altered in some way. In the past lumber mills used the creek as a source of energy, but after they shut down in the 1960s and 1970s, there was little interest in the creek (Pinkham, 2000). In 1990, Arcata High School proposed to daylight a section of the creek which ran underneath an area of the school grounds that had been neglected. With the help of Humboldt State University, construction began in 1991 (Ekman and Murphy, 2000). Since that time, additional projects have been completed further downstream (Pinkham, 2000).

Design

Approximately 49 m of culvert was removed at Arcata High School and was replaced by a sedimentation basin, a pond, and a length of new stream. Structural diversity was included as part of the design in order to provide habitat both within and outside of the creek. The design allows for easy accessibility as the new system is used as an outdoor laboratory for the high school (Ekman and Murphy, 2000).

Involvement

Beyond Humboldt State University and Arcata High School, community groups, and government programs representing all three levels of government were involved (Pinkham, 2000).

Results

The project has created a valued natural area for the community as well as an outdoor laboratory for the school. Many students were involved in the restoration project itself, which has influenced their choice of studies after high school (Pinkham, 2000).

A.1.7 Phalen Creek – St. Paul, Minnesota

Location

The daylighting project that occurred on Phalen Creek took place in an area near downtown St. Paul, Minnesota known as Swede Hollow Park (Friends of Swede Hollow

Park, 2000). The park is the only daylighted section of Phalen Creek, as after it passes through the park it enters a culvert until it discharges into the Mississippi River (Pinkham, 2000).

History

The Swede Hollow Park area has historically been a low-income area. As development increased, the creek was culverted over the years. In 1956 the city condemned the area, and throughout much of the 1960s the area was neglected. In the 1970s community interest grew and the city created Swede Hollow Park. Failing storm water infrastructure in the 1980s lead to the idea of daylighting Phalen Creek, however, a full daylighting was not perceived as feasible. Instead a portion of the water that makes up Phalen Creek was daylighted in 1987, while the remainder remains buried (Pinkham, 2000).

Design

The project is composed of a series of ponds, culverts and a daylighted section for a total of 640 m of surface water. The movement of the creek is controlled by the culverts, and Phalen Creek is only allowed to assume a more natural meandering course for a portion of the length of the project. At the end of this meandering section is the third and largest pond where water is drained away to continue its journey in a culvert (Pinkham, 2000).

A high proportion of the water for this project used to come from cooling tower effluent discharged from two nearby industries. One of the industries treated its effluent with biocide, and up until the plant's closure in 1998, the creek was not able to support much aquatic life (Pinkham, 2000).

Involvement

This project involved the Friends of Swede Hollow Park, other community organizations, the City of St. Paul as well as representatives from state and federal government offices (Friends of Swede Hollow Park, 2000).

Results

This project created a valued community amenity as well as instigated further proposed projects to daylight other sections of Phalen Creek (Pinkham, 2000).

A.1.8 Spanish Banks Creek – Vancouver, British Columbia

Location

Spanish Banks Creek drains a watershed located on the University of British Columbia Endowment Lands and Pacific Spirit Park in Vancouver, British Columbia. The area is mostly undeveloped, and so the creek's flow is largely unregulated for the majority of the creek's length. Near the terminus of the creek, at Spanish Banks on English Bay, the creek had been placed in a culvert in order to direct its flow underneath N.W. Marine Drive and a parking lot servicing the park. Farther up in the watershed, there is a small residential development (City of Vancouver, 1999b).

History

Spanish Banks Creek historically was a salmon-bearing creek supporting populations of Coho and chum salmon; however, fish populations disappeared in the last 50 years because of urban development (Miller, 2000). The culvert further restricted access to the upper reaches of the watershed and prior to the project the creek was barren.

Design

The creation of salmon habitat was the primary goal behind the Spanish Creek daylighting project. The project began in September 1999 when approximately 52 metres of culvert were removed between the ocean and N.W. Marine Drive, so that the creek now crosses both the parking lot and beach area (City of Vancouver, 1999b). Approximately 10 parking stalls were lost. Pools, riffles, spawning gravel, boulders and woody debris were installed along with native beach grass (Miller, 2000). Coho and chum fry have been released in the creek in hopes of establishing small spawning populations, but it is too early to judge the project's success. The total cost for the project was approximately $80 000 (City of Vancouver, 1999b).

Involvement

This was a joint project of the Federal Department of Fisheries and Oceans, B.C. Provincial Ministry of the Environment, Vancouver Salmon and Stream Society, West Point Grey Residents Association, Coast River Environmental Services and private sponsors (City of Vancouver, 1999b).

Results

There has been mixed community reaction to the project. Some community members have gone so far as to assume a care-taking role of the project, while an outspoken environmentalist has been reported as saying that the "effort put into habitat restoration at Spanish Creeks could have been better spent elsewhere" (Miller, 2000). Recent flooding has modified the original design, leading to the need to remove silt and the creation of a marshy area. The new additions are seen as improvements to the overall design (Page, pers. comm.) although it is too soon to say if the re-stocking efforts have been successful.

A.1.9 Strawberry Creek – Berkeley, California

Location

The project is located within the City of Berkeley, California on a former abandoned rail yard (Pinkham, 2000). The creek flows through the University of California campus before it is placed in a culvert in order to cross the downtown. The area around the project is mixed use (Charbonneau, 1987).

History

Strawberry Creek is an important cultural feature to the City of Berkeley – in fact, the College of California (now the University of California) chose its present site in 1860 because of the creek (Charbonneau, 1987). As with other urban creeks, Strawberry Creek was seen as an easy means to dispose of sewage, and complaints about water quality came as early as the late 1800s. Culverts were built to carry the flow underground, and the creek's presence in the community was lessened (Charbonneau, 1987).

The rail yard upon which this daylighting project would take place, was abandoned in 1974 and lay neglected until 1982 when a city landscape architect proposed a new plan for the property focusing on the daylighting of Strawberry Creek. Initially the public was not behind the idea fearing for public safety, but by 1984, attitudes in the community had changed, and the project had been completed (Pinkham, 2000).

Design

The park focus is on 61 m of daylighted creek. Consultants tried to recapture the shape of the original creek as much as possible and landscaped the remainder of the 4 acre park so that run off would flow into the creek bed. Native vegetation was used to revegetate the slopes. The total cost of the project was $580 000 US, and approximately $58 000 US was used specifically for the daylighting (Pinkham, 2000).

Involvement

The project initially involved the City of Berkeley and its consultants, but now includes a innovative work program for youth at risk. Along with four other city parks, Berkeley Youth Alternatives hold a contract to maintain Strawberry Creek park (Pinkham, 2000).

Results

The project is seen as a success by the City of Berkeley. Many people visit the park every day, most specifically for the creek. The success of this project has recently been the impetus behind an idea to daylight further sections of Strawberry Creek through the downtown (Wolfe Mason, 1999).

A.1.10 Taddle Creek – Toronto, Ontario

Location

Taddle Creek used to flow through the heart of what is today downtown Toronto, from its source near Davenport and St. Clair, south to its mouth at Lake Ontario, near present day Front and Parliament Streets (Hasemi, 1998). The area today is mostly developed, except for the occasional open space (University of Toronto, 1998).

History

Taddle Creek was a prominent feature in the city up until the late 1880s when it, along with other streams in the city that had become open sewers, was buried in a brick combined sewer (University of Toronto, 1998). Pollution levels reached the point where people complained of the 'noxious smells' and worried about the health of residents. The creek was buried in sections, the last section to be buried being on the grounds of University of Toronto in 1884 in an area that is now known as Philosopher's Walk (University of Toronto, 1998). Community support for restoring Taddle Creek in some fashion has been growing, and in 1997, a class at the University of Toronto spent an entire year developing proposals for a daylighting project (University of Toronto, 1998).

Design

The focus for daylighting Taddle Creek is on Philosopher's Walk - the last section to be buried, and still most visible reminder of the creek's former run. Several options were examined ranging from full daylighting of the combined sewer to a daylighting supplemented by re-routed storm water to doing nothing. The favoured option was a shadow creek composed of re-routed storm water supplemented with municipal water for a section of water no longer than Philosopher's Walk (a couple of blocks) (University of Toronto, 1998).

Involvement

Although this project is still in conceptual stages, there has been interest from a variety of groups including the University of Toronto, the City of Toronto, and the Taddle Creek Watershed Initiative (University of Toronto, 1998). The Taddle Creek Watershed Initiative is composed of a number of community groups and conservation organizations (Taddle Creek Watershed Initiative, 2000).

Results

There have been no physical results as of yet; however, momentum behind the idea is still strong, and the University of Toronto may consider daylighting a section of Taddle Creek in some fashion as part of its new Open Space Plan (University of Toronto, 1998).

A.1.11 Thain Creek – Vancouver, British Columbia

Location

Thain Creek cuts through both the City of North Vancouver and the District of North Vancouver in British Columbia. The creek is a tributary of Mosquito Creek, which empties directly into Burrard Inlet. For the majority of its length, Thain Creek flows unimpeded (Mosquito Creek Stewardship Society, 2000). Although the lower part of the watershed had been extensively logged in the past, regrowth has occurred (City of North Vancouver, 2000). The upper reaches have experienced more development and the creek runs in a culvert in several places (Mosquito Creek Stewardship Society, 2000). There are barriers further upstream from the daylighted section that are being investigated as potential future daylighting projects (Mosquito Creek Stewardship Society, 2000).

History

In 1958, Thain Creek was diverted into a wooden culvert because of an increased risk of flooding because of new developments in the upper watershed throughout the 1950s (City of North Vancouver, 2000). This culvert prevented spawning fish from traveling further upstream, and was too small according to present day engineering standards (City of North Vancouver, 2000). Although there has been no account of anything larger than a 40-year flood (Barber, pers. comm.), the culvert was required to have the capacity to convey a 200-year maximum flood flow, and in addition, the culvert was deteriorating (City of North Vancouver, 2000). Heavy rains in 1997 caused part of the culvert to collapse and so the decision was made to implement changes at this section of Thain Creek (City of North Vancouver, 2000).

Design

The solution was primarily designed for flood control; however, ecological aspects were included (City of North Vancouver, 2000). Two hundred meters of the culvert were removed, opening up a relatively straight section of Thain Creek (City of North Vancouver, 2000). The section is not wide, approximately fifteen meters, and allows little room for natural meandering (Page, pers. comm.). Pools and riffles have been included in order to aid spawning fish (Mosquito Creek Stewardship Society, 2000). In addition, the banks of the creek were re-vegetated with the idea of increasing bird habitat (City of North Vancouver, 2000). Construction costs for this project were $1.4 million, for a total approximate cost of $1.7 million (Barber, pers. comm.).

Involvement

This project was the result of cooperation between several organizations. These are adjacent neighbours, Mosquito Creek Stewardship Society, North Shore Stream Keepers, BC Ministry of Environment, Department of Fisheries and Oceans, the City of North Vancouver, and the District of North Vancouver (City of North Vancouver, 2000).

Results

Both spawning activity and emergent fry have been observed; however, numbers have not been quantified (Barber, pers. comm.). There has also been positive public reaction to the project (Barber, pers. comm.). After one year of operation, project consultants returned to the project in order to make minor modifications due to siltation (Page, pers. comm.).

A.1.12 Valley Creek – Port Angeles, Washington

Location

Valley creek flows unimpeded through a largely forested and undeveloped watershed until it reached Port Angeles. There it first passes through a residential area, and then is culverted when it enters an industrial area of town. The culverted creek empties into the Strait of Juan de Fuca on grounds managed by the Port of Port Angeles, a special district indirectly affiliated with the City of Port Angeles (Pinkham, 2000).

History

The area of interest to this project is occupied by the K-Ply plywood mill who up until the late 1980s used primarily cedar. At this time, regulations changed, and so K-Ply turned to cottonwood and along with the change of supply, K-Ply needed to change operations. These change of operations required the filling in of a pond that had previously been used to store cedar. State regulations required mitigation for lost wildlife habitat, and so K-Ply, along with the Port, proposed to daylight Valley Creek's estuary. Construction began in 1997 (Pinkham, 2000).

Design

During construction, the estuary was dug out and the soil used to fill in the pond. One hundred and forty nine metres of culvert were removed, and habitat enhancement features were added. Along with the 1.1 Ha estuary is a new 0.42 Ha park for the city that is described as part of an effort to revitalize the downtown. The total cost of the project was $1 million US, which was jointly shared by the project partners (City of Port Angeles, 2000).

Involvement

This project directly involved the Port of Port Angeles, K-Ply Plywood, as well as their major partner, the Soroptimist International of Port Angeles Noon Club who were able to fundraise and get other community groups and corporations involved (Soroptimists of the City of Port Angeles, 2000).

Results

The park is a popular destination for residents and visitors to downtown Port Angeles. There has also been interest in daylighting additional sections of Valley Creek (Soroptimists of the City of Port Angeles, 2000).

A.2 Summary

Creek daylighting projects have been performed for a variety of reasons – aesthetic improvements or storm water management being most often listed as primary objectives. The high costs of some projects may be a problem if the municipality has a false perception about their value as urban conservation, if they are ineffective at doing this. This would take money away from more effective projects. That most projects do not connect waterways but instead are merely a break in a culvert suggests that the conservation value of some of these projects is limited.

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PERSONAL COMMUNICATION

Barber, T. City of North Vancouver Representative, North Vancouver, BC January, 2001.

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