THE TATLOW CREEK REVITALIZATION PROJECT

by

SUSAN OLUCIA MILLEY

B.F.A., The University of British Columbia, 1998
Dip., Art Hist., The University of British Columbia, 2000

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

MASTERS OF LANDSCAPE ARCHITECTURE

in

THE FACULTY OF GRADUATE STUDIES

(Department of Landscape Architecture)

We accept this thesis as conforming
to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

November 2003

Department of LANDSCAPE ARCHITECTURE

The University of British Columbia
Vancouver, Canada

Date OCTOBER 10TH 2003

THE UNIVERSITY OF BRITISH COLUMBIA

ABSTRACT

THE TATLOW CREEK
REVITALIZATION PROJECT

by Susan Olucia Milley

Chairperson of the Supervisory Committee:
Professor Patrick Condon
Department of Landscape Architecture

My project deals with one of the greatest resources on earth: water. Increasing populations and land development requires increased responsibility to preserve and enhance natural hydrologic processes as much as possible. But most often, current development and engineering practices do not recognize this growing responsibility, as urban water courses have been buried and / or culverted beneath the ground. Rainwater has been given an "out of sight out of mind" treatment as it is funneled into vast and expensive sewer system networks which leads to expensively and unnecessarily treated water, and destroys the natural recycling process of the hydrological system which recharges our water resources. One method of regenerating the hydrological system is by revealing, or 'daylighting' buried streams, and by implementing measures which will sustain them in their complex urban contexts.

Streams within the Greater Vancouver area were once common. Now few streams remain in this urban landscape, and fewer yet are healthy enough to support their once-thriving fish habitats. Healthy streams and their environments create diverse habitats for

animals and plants, create pathways for movement in the larger landscape, reduce flooding of larger water bodies and reduce the amount of water being unnecessarily treated with sewage. Furthermore, streams give character and identity to the landscape and foster in people a greater sense of ecological recognition, community pride, value, and stewardship. My research is based on my belief that by re-introducing streams back into our urban fabric and designing effective stormwater design strategies to sustain them, we can greatly enhance and benefit both the ecological environment as well as our city communities.

My thesis presents a model for daylighting Tatlow Creek; an urban stream in the Greater Vancouver district of Kitsilano. This model strives to: 1) Daylight Tatlow creek North under Point Grey Road, through Volunteer Park and into English Bay 2) Naturalize the riparian area 3) Restore the creek's base flow by suggesting short and long-term strategies for infiltration throughout the Tatlow Watershed.

Tatlow Creek presents a unique opportunity in which to propose a viable system of green infrastructure which thoroughly integrates an urban park with its medium-density urban context. This system designs for a strategically planned and managed network of green spaces and corridors interconnected with an existing urban environment, which supports native flora and fauna, sustains water resources and natural hydrological processes, and contributes to the health and quality of life of the community. The district of Kitsilano currently possesses many positive aspects of sustainable ecological design, and as such presents a favourable practicability for adapting and retrofitting these with a long term design strategy for its entire watershed. This would then eventually connect with an expanded green infrastructure network throughout the greater Vancouver region.

TABLE OF CONTENTS

LIST OF FIGURES

ACKNOWLEDGEMENTS

I would like to express my gratitude to the members of my committee for their support and guidance; Professor Patrick Condon, Dr. William Marsh, Nick Page and Maged Senbel.

PREFACE

"Imported Sequoia trees add an air of dignity to Tatlow Park, where they tower above short-cropped grass and the remains of a long-ago-tamed stream. What remains of Tatlow Creek...is a tiny trickle of water—from a leaking water pipe—guided by rounded rocks carefully placed along its bank..."

Gareth Kirkby,
The Georgia Straight, Vancouver, BC, May 29th, 1997

F O R E W O R D

Tatlow Creek was scheduled to be daylighted. The idea came about in 1995 when the West Kitsilano Residents' Association formed a group to investigate the possibilities of such a project. In 1996, they, along with staff of the Vancouver Parks Board, City Engineering, and the Department of Fisheries and Oceans, had a meeting together to discuss the feasibility of this endeavour. City engineers maintained that indeed, storm water could be diverted back to a natural creekbed and tunnelled under Point Grey Road. The project was set to be implemented in 1997.[1]

---

[1] SFU (n/d). A Strategic Concept Plan for A Model Sustainable Community in South-East False Creek, Simon Fraser University's Geography 449 class: Environmental Processes and Urban Development.

http://www.sfu.ca/cedc/students/geogclass/grnanbib.htm

INTRODUCTION

My design goal in the Tatlow Creek Revitalization Project is to daylight the existing urban creek to its mouth at English Bay and to design for its sustained and healthy baseflow. My objectives in accomplishing this goal are: 1. To connect the existing creek channel across a busy road and to design an adequate stream channel and floodplain appropriate to the site conditions and 5-year stormwater volumes; 2. To design a suitable riparian environment for the proposed and existing creek channel; and 3. To suggest gradual design transformations which would turn the existing "hard, impervious and grey" urban infrastructure into a "soft, pervious and green" infrastructure. My designs illustrate a proposed stream channel retrofitted into an existing urban context, in partnership with a suggested incremental retrofit and redevelopment of the watershed area to infiltrate stormwater which would then ensure a sustained creek baseflow. This would have additional benefits, including increased stormwater quality and quantity control, and decreased dependence on sewers, culverts, and other expensive means of channeling water. By taking advantage of freely available natural processes, I aim to manage precipitation as close to where it falls as possible and design for a "green infrastructure" to replace costly conventional infrastructure for stormwater storage, treatment and management.

1.1 The Importance of Daylighting

Urban streams are an important but continually disregarded part of the landscape. Daylighting streams provides many benefits, including: Relieving under-capacity stormdrains and culverts; reducing runoff velocities thereby helping to prevent erosion, property damage and habitat loss; replacing old and damaged culverts with an open drainage system that is more accessible and can be more easily repaired and monitored thus reducing costs; diverting urban runoff from combined sewer systems before it mixes with sewage thereby reducing combined sewer overflows into English Bay and costly burdens on the Iona treatment plant; improving water quality entering English Bay by exposing water to air, sunlight, vegetation and soil- all of which help filter and neutralize pollutants; creating fish, aquatic habitat and riparian habitat and linking greenway corridors for wildlife and pedestrian movement; providing active and passive recreational value for all ages; serving as an educational "nature laboratory" for urban schools; beautifying neighbourhoods; increasing property values; benefiting nearby businesses by attracting people to the area; creating job opportunities in building and maintaining the stream and park; building civic spirit and fostering community relationships; reconnecting people to nature through the look, feel, smell and sound of open water, riparian vegetation and aquatic and terrestrial life; fostering a sense of "existential insideness"[2] by creating a vibrant and profound sense of place which people will be more likely to cherish and nurture.[3]

Furthermore, the Greater Vancouver Regional District is expected to experience significant population growth over the next 50 years, and the increased urban densification and land development will increase the rate and volume of stormwater runoff. Consequently, this will have several effects including the need for upgrades and repairs to drainage infrastructure; increased risk of flooding; and increased pressure and damage to water quality and aquatic systems.[4]

1.2 Methodology

The methodology I am using for my design is that of "stormwater source control", a proactive approach which aims to capture rainfall at or near its source and subsequently return it to its natural hydrologic pathways by infiltrating it into the ground, and allowing the water to travel by interflow; subsurface pathways which flow laterally towards a

[2] A meaningful term coined by Edward Relph in his book Place and Placelessness, 1976.

[3] List adapted from Pinkham, R. (2000). Daylighting: New Life for Buried Streams. Old Snowmass, Colorado, Rocky Mountain Institute, i-iv.

[4] CH2MHILL (2002). Effectiveness of Stormwater Source Control. Vancouver, Greater Vancouver Sewerage & Drainage District, 2.

streambank or other depression which intersects the water table.[5] Alternatively, rainfall can be intercepted by vegetation, depression storage pockets for longer term infiltration, or it can be dispersed through the air by evapotranspiration. A target condition for stormwater source control methodology is for at least 90% of all rainfall to be returned to these natural hydrologic pathways or for it to be reused at or close to its source, since research shows that once the imperviousness of an area exceeds 10%, stormwater related impacts begin to occur.[6] This is accomplished primarily by turning as much of the watershed over to pervious and vegetated soil as is possible. Consequently, my designs include retrofitting streets, sidewalks, roofs and other impervious surfaces to either absorb or infiltrate water runoff, or to convey it to cisterns, dry wells, or other suitable vegetated infiltration pockets such as swales or wetlands. This process incorporates retrofitting existing engineered infrastructure such as curbs and catch-basins to accommodate these changes. Additionally, planting deciduous and evergreen trees will intercept rainwater year-round, to evaporate from leaves or more slowly infiltrate into the soil.

---

[5] Marsh, W. M. (1998). Landscape Planning: Environmental Applications. New York, John Wiley & Sons, Inc, 185.

[6] CH2MHILL (2002). Effectiveness of Stormwater Source Control. Vancouver, Greater Vancouver Sewerage & Drainage District, 1.

1.3 Tatlow Creek

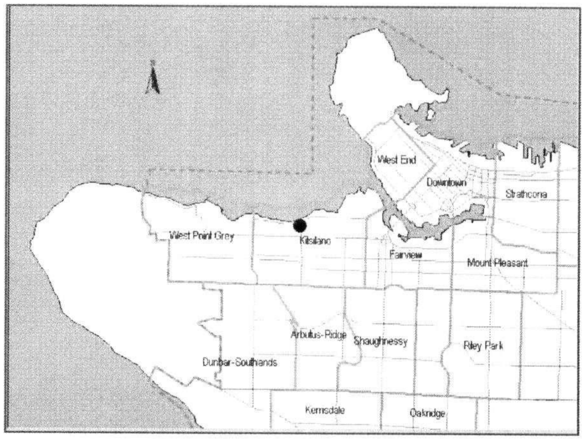


Figure 1 Showing the location of Tatlow Park in Vancouver

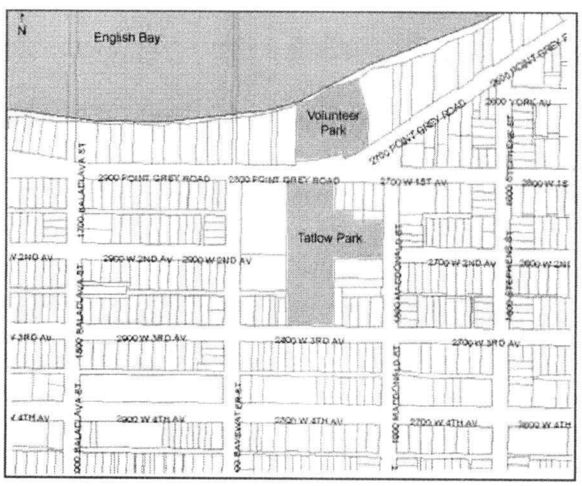


Figure 2 Tatlow and Volunteer Parks

Tatlow Creek, or First Creek, is located in Tatlow Creek Park, a 1.41 hectare area in the mainly residential district of Kitsilano **(Figure 1)**. The park is bounded by Point Grey Road on the North, West 3rd Avenue on the South, MacDonald on the East and Bayswater on the West **(Figures 2, 3)**. The entire Tatlow Creek Watershed area (the catchment area) was about 1.41 km^2, with its headwaters being close to Marguerite and Matthews avenues **(Figure 4)**.[7] Like any natural stream, the continual presence of water in Tatlow Creek was guaranteed by the gradual and steady conveyance of groundwater to it. This is water

[7] Piteau Associates (2000). Restoration of First Creek, Tatlow Park, Vancouver, 1.

which has infiltrated and filtered through the ground, gradually resurfacing where the stream bed intersects the water table.[8]

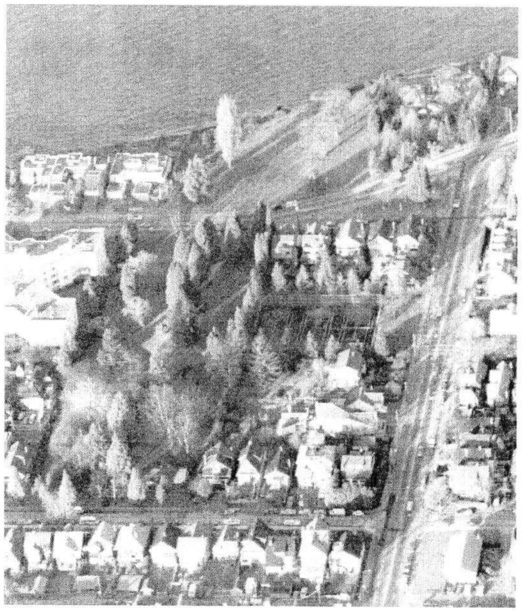


Figure 3 Aerial View North

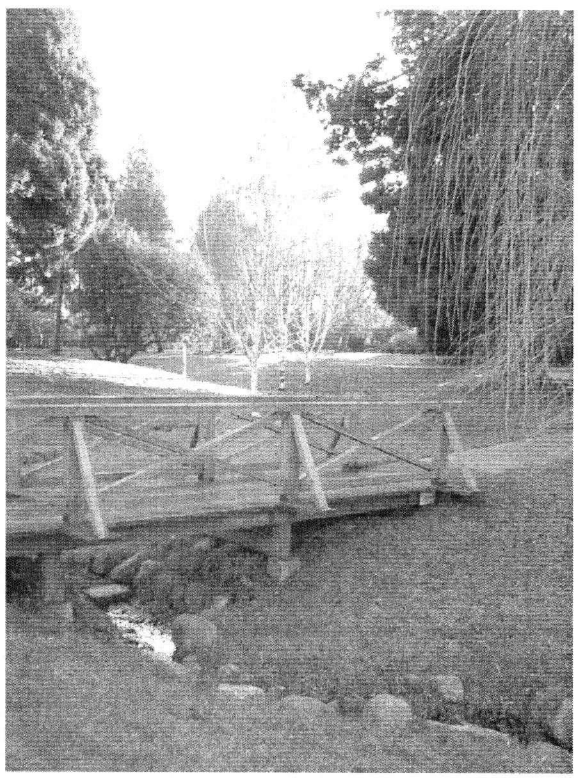
Such a steady supply of water to the stream would thereby constitute the Creek's baseflow during both dry and wet periods. According to an old-time resident in the area, the creek channel north of 4th avenue was in a deep gully until the 1920's when it was filled in, partly with city garbage. Furthermore, the presence of sedge grass in the intertidal zone along the shoreline indicated that a regular freshwater outflow was present, and like many healthy streams, Tatlow Creek supported spawning fish populations, namely salmon and trout, until about the turn of the century.[9] Additionally, one of the primary goals of the Salmonid Enhancement Program of the Department of Fisheries and Oceans is the restoration of salmon stocks. One of the main techniques which this employs is

---

[8] Marsh, W. M. (1998). Landscape Planning: Environmental Applications. New York, John Wiley & Sons, Inc, 185.

[9] Piteau Associates (2000). Restoration of First Creek, Tatlow Park, Vancouver, 1.

"the removal or passage around manmade barriers to allow anadromous salmon access to historic habitats"[10] This information justifies the suitability of Tatlow Creek as an appropriate candidate for daylighting.



[10] Foy, M. (1997). Restoration in the Lower Mainland. Urban Stream Protection, Restoration and Stewardship in the Pacific Northwest: Are we achieving desired results?, Douglas College, New Westminster, Quadra Planning Consultants Ltd, 76.

Figure 4 The Original Tatlow Creek stream course and watershed area (kidney shaped outline). The shaded area is the engineered watershed consisting of curbed roads, catch-basins and pipes. The roman numerals indicate separate catchment areas.

Surficial sediments within the watershed are typical of the Greater Vancouver area; a mixture of glacial drift consisting of silty sediments broken up by pockets of sand, gravel and stony silt, and along the English Bay shoreline, sedimentary bedrock is exposed.[11] Geotechnical engineering surveys have shown that these sediments

[11] Piteau Associates (2000). Restoration of First Creek, Tatlow Park, Vancouver, 2.

have a "relatively low permeability, however experience with excavation in the area suggests that there are some localized pockets of more permeable sand units in the area".[12] Indeed, numerous studies of soil characteristics within the greater Vancouver area suggest that there exist enough pockets of sand and gravel interspersed within the sub-surface sediments as to ensure a regular infiltration capability. In one case study conducted by the James Taylor Chair, stormwater infiltration in Amble Greene, Surrey, was successfully achieved using natural infiltration methods, in a soil profile comprised of the same layers as those found in the Tatlow Creek watershed: "...a layer of topsoil, which varies in thickness from 0.1 metres to 0.5 metres, above a fairly compacted layer of gravely sandy soil, which reaches depths of 2.0 metres. Immediately below this gravely soil, is a more impervious layer, which is referred to as 'hardpan' and composed of fine sand and silty-clay."[13]Moreover, subsequent evaluation of the site to date claims: "Overall, the project has been successful at minimizing stormwater runoff from the site. And, despite the underlying hardpan layer impeding the flow of water to the deeper water table, the soil layer above the hardpan layer acts effectively as a reservoir during

[12] Ibid.

[13] Condon, P. (2000). Amble Greene, District of Surrey, BC Alternative Stormwater Management Systems: Technical Bulletin. Vancouver, The James Taylor Chair in Landscape & Liveable Environments, 2.

saturation periods. It appears that these 2 metres of generally compacted soil have adequate storage capacity for even the 100-year storm. (There have been two hundred-year storms since the project was built). There are no discharges of stormwater from the infiltration-based portions of the site. Due to the effectiveness of the stormwater system at Amble Greene, ninety five percent of the developer's contributions for [conventional] downstream drainage facilities were rebated 2 years from the end date of construction."[14]

Further characteristics of the Tatlow Creek hydrogeology were described in a report for the city of Vancouver by Klohn-Crippen Consultants Ltd., which attributed the watershed as being within a "groundwater discharge zone". These are zones in which there is a "net migration of groundwater toward the ground surface, which results in shallow water tables and an all-year-round discharge to surface channels, which typically sustains creek baseflows. Since then urban development, including house and infrastructure construction, has likely created a deeper water table in many places.[15]

Given that the area is within a groundwater discharge zone, in addition to the interspersed pockets of permeable sand within the

[14] Ibid, 3.

[15] Piteau Associates (2000). Restoration of First Creek, Tatlow Park, Vancouver, 3.

ground and a "considerable northward groundwater gradient"[16] the site provides the basis for a functioning creek with sustained baseflows and an opportunity to revitalize its once- plentiful salmon population, if appropriate designs can be retrofitted into the existing urban context.

1.4 The Water Source

By implementing stormwater source control methodology into my design, I aim to restore a sustained baseflow to Tatlow Creek. To create an immediate, short-term baseflow in the creek however, this involves employing the city's pipe-separation project. The Vancouver engineering department is currently changing the city's sewer system from a combined system (where storm and sanitary sewer flow

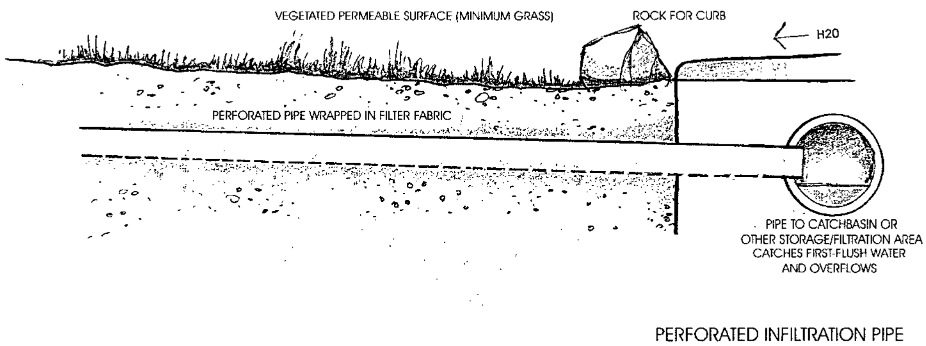


Figure 5

[16] Ibid., 3.

together in one pipe) to a separated system with pipes for each. Their goal is to remove all combined sewers by 2050.[17] My design proposes to only lay the sanitary sewer pipe, and replace the storm pipe function with a network of perforated pipes which allow rainwater immediate infiltration capability **(Figure 5)**.

Such pipes are to be located under roadside swales and along the edges of impervious surfaces which generate sheet flow (driveways, tennis courts...). If and when flooding occurs, these swales, pervious streets and green corridors are designed to act as existing roads do- to store or channel and convey excess water to a safe flooding area. In this case, such a place could be a park, other greenspace, wetland, or even a larger body of water such as English Bay **(Figure 6)**. In the Vancouver region, swales can absorb 24mm of water per day during winter, and water will enter the perforated pipes only after the swale has become saturated.

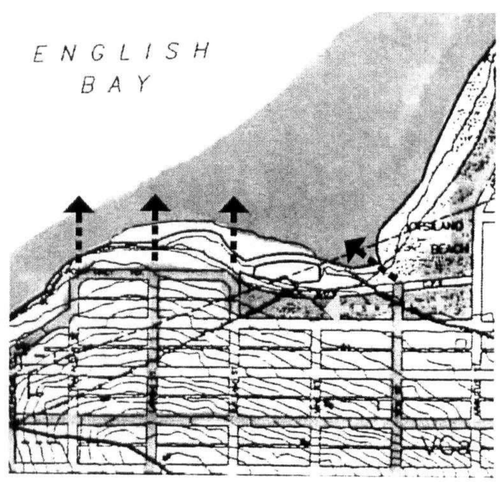


Figure 6 Detail showing green corridors conveying excess stormwater to English Bay

[17]City of Vancouver (2003). Broad City Initiatives, http://www.city.vancouver.bc.ca/sustainability/initiatives.htm.

Swale sizes can also be varied to intercept interflow farther beneath the ground.[18] Through these means, a more immediate source of infiltrated water will recharge Tatlow Creek. However, as the changeover to infiltration pipes and a green infrastructure network is gradual and piecemeal, the creek may not be able to maintain baseflow in the short-term. In this case it may be necessary to augment the infiltrated water flow with tap water from the existing GVRD pipe, and to employ a shut-off mechanism to ensure that the creek does not receive a disproportionate volume of water in relation to its designed capacity. This reinforcement would then be phased out over time, as more and more of the watershed area will be connected with green infrastructure which will absorb, filter, and channel water which will recharge the creek and ensure it receives a naturally sustained baseflow.

1.5 Site Analysis

Currently, the Tatlow Creek Watershed is comprised of medium density residential and commercial areas. The landscape as such is made up of various built layers including roofs, roads, driveways, foundations and pipes, which make up a large percentage of impervious areas. Beneath the streets, the integrated network of sub-

[18] Condon, P. (2003). Green Municipal Engineering for Sustainable Communities, http://www.sustainable-communities.agsci.ubc.ca/bulletins/municipal_engineer_article.pdf.

surface stormdrains function to override the sites' natural hydrological processes and is delineated by the large shaded area in figure 4. This area represents the engineered system of catchbasins and pipes, and it can be seen that all of this contributes to a very large percentage of imperviousness as stormwater is funneled and directed through the system to the waste treatment plant, or spills out with raw sewage via overflow pipes into English Bay during large storms. Controlled in this way, stormwater has no occasion to meet the ground and therefore cannot recharge the groundwater which subsequently feeds into and maintains stream baseflows.

A number of greenspaces dot the watershed area, including those in schoolyards, fields, boulevards, and most notably the unique pocket parks nestled between the prime residential properties strung along the English Bay shoreline. One such greenspace is Volunteer

Figure 7 View of Volunteer Park, looking south towards Point Grey Road

Park, which is located directly north from Tatlow Park across Point Grey Road (Figure 7).

Historically, the route of Tatlow Creek ran through the west side of this park to its mouth at English Bay, and as an existing greenspace, Volunteer park makes a predictably appropriate location through which Tatlow Creek should continue to flow.

1.6 Opportunities

Though urban development in the area increased imperviousness and disrupted the natural hydrological recharge capabilities of the ground in the watershed, the site nevertheless presents many opportunities for achieving the gradual transformation of the hard, grey, impervious infrastructure into a soft, green, and pervious system to replenish creek baseflows and provide for a more sustainable, cost-effective arrangement to create urban and ecological revitalization and rehabilitation. One such opportunity exists through the previously mentioned pipe-separation construction undertaken by the City of Vancouver, which provides the capability to replace the old, conventional pipe systems with the new green infrastructure which lets stormwater permeate into the ground or travel through a networked series of trenches to specific green, "flood-out areas" which can also provide biofiltration for the water. When taking advantage of the many existing greenspaces and edges in the area, they can provide places for creating wetlands which serve as areas of stormwater detention, filtration, valuable habitat, as well as spaces for learning.

This additionally presents increased long-term savings from costly pipe laying and curb construction when integrated into a larger arrangement with green roads.

Another opportunity for implementing the green network is with regard to the significant population growth which the Greater Vancouver Regional District is expected to experience over the next 50 years. As Greater Vancouver's population density increases, many older residential and commercial buildings will need to be re-built, renovated or retrofitted. Consequently, these buildings could be integrated to support the green infrastructure system. Minimally, roof leaders and gutters could be disconnected from the storm sewer system and otherwise diverted into swales and wetlands for bio-treatment and infiltration. Designs for development for zoning and land use could be reconciled and structured in accordance and compatibility with the objectives of the new, green, goals and objectives, and local codes such as those for plumbing, building, street design, drainage and property management could also be modified or eliminated, if incompatible. In order to assure watershed-wide restoration and redevelopment goals, a coordinating procedure should be set up to review redevelopment plans to guarantee the success of ecosystem development objectives and to verify that projects do not contradict each other. Education is vital to such an initiative, and developers, citizens, and city officials would work more effectively towards realizing long-term goals if broader-scale linkages within the system are better understood.[19]

Undoubtedly, significant re-development of an entire watershed area will take many years as such progress is incremental. Nevertheless, the important part is to begin, and my designs aim to present the beginning of such a change.

1.7 Constraints

Creating a soft infrastructure in a hard environment creates the issue of how to deal with the existing layers which more often than not impeded such construction and retrofitting. Designing a bridge underneath Point Grey Road, for instance, necessitates the retrofit of a structure which would be able to circumvent, yet incorporate, the large utilities beneath it. Such construction naturally accrues an initially large pricetag, but the cost of this retrofit coupled with a green infrastructure plan, would be subsidized in the long run, as costs associated with conventional "grey" construction are thereby reduced or eliminated.

[19] Ferguson, B. (1999). Re-Evaluating Stormwater: The Nine Mile Run Model for Restorative Development. Snowmass, Colorado, Rocky Mountain Institute, 29.

Another apparent constraint lies within the fact that this is, after all, a constrained urban area, and designing for a healthy creek requires a substantial riparian zone and floodplain. The Department of Fisheries and Oceans defines a substantial riparian zone as "at least 15 metres from each side of the watercourse, from the high water mark, in a residential/ low density area."[20]Because the largest distance between high water mark and urban edge in my design is 15 metres, this is technically a constraint. However, I believe that my proposed landscape designs and infrastructure retrofits filter and convey water more effectively than a more substantial buffer would in a 'natural' creek situation. As a result of these interventions, my design accounts for the loss of these extra metres of riparian area.

A more physical drawback in designing the proposed creek channel through Volunteer Park relates to the topography and geology of the site. The north end of the park is flanked by a 3.5 metre high bluff, and the erodible sedimentary makeup of the soil prevents the channel from lying at more than a 10% grade without significant armouring. This limitation has been taken into account in my ensuing channel design.

---

[20] Chilibeck, B. (1993). Land Development Guidelines for the Protection of Aquatic Habitat, Ministry of Environment, Lands and Parks, Integrated Management Branch, 18.

D E S I G N S

2.1 Existing & Proposed

Tatlow Park is a picturesque park within a residential neighbourhood. It includes some of the city's oldest Sequoia trees, and white birches line its gently sloping grass-covered banks **(Figure 8)**.

Figure 8 Tatlow Park

Figure 9 Tap water entering Tatlow Creek

It is a quaint park straight out of a fairy tale, and as such is popular for weddings and family picnics.[21] However, the park does not represent a natural, functioning stream environment.

Tatlow creek is an existing 55 metre section within the park, and is fed by tap water during the

[21] Douglas Paterson, personal communication, January, 2003, UBC.

summer months which enters the creek by way of a GVRD pipe **(Figure 9)**. This is noted as the spot where the creek begins, in figure 10. From this contrived source, the clear, chlorinated water flows tentatively amongst strategically placed stones through the irregular, mud-lined channel to finally exit the park, intermittently, under a culvert adjacent to Point Grey Road **(Figure 11).** It is speculated that the water eventually discharges from the old culvert

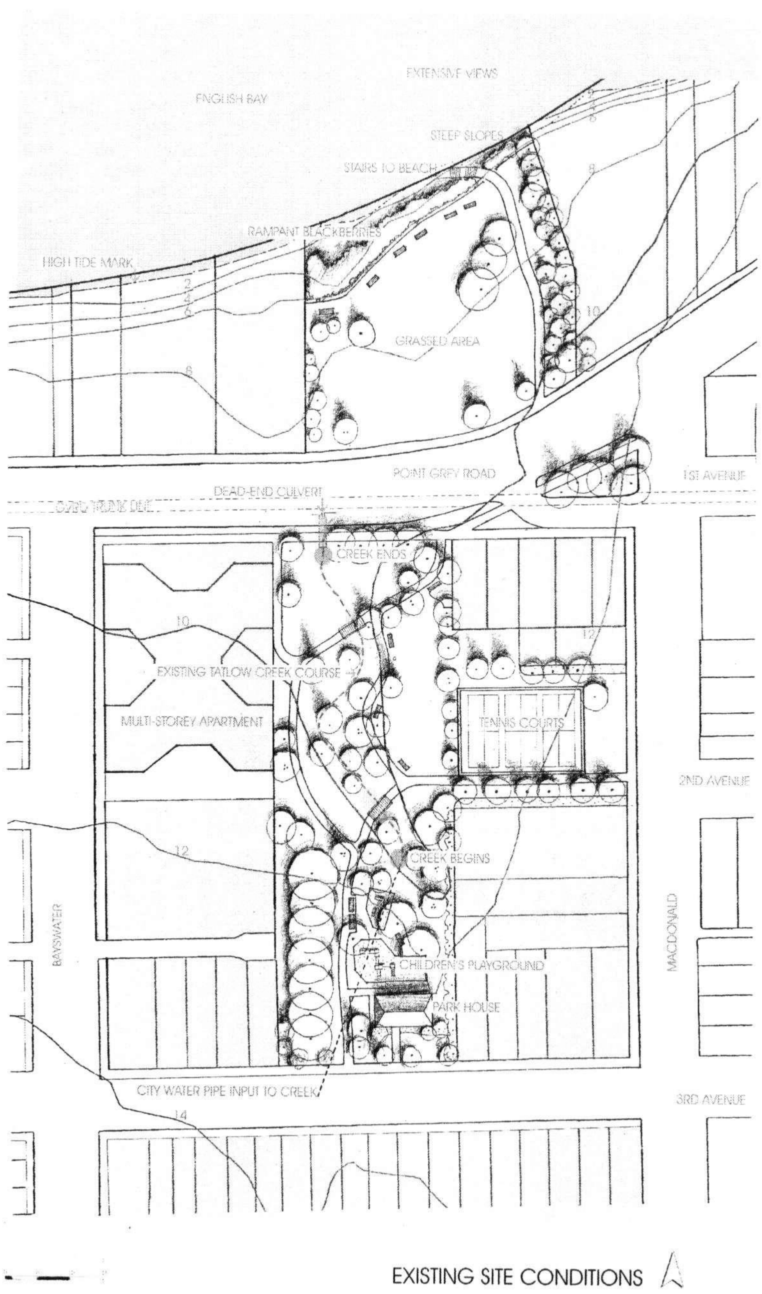


Figure 10

into English Bay.[22] This culvert is shown in figure 10 as at the location where the creek ends.

Figure 01 Culvert under Pt. Grey Rd.

Fortunately, the location and site conditions of Volunteer and Tatlow parks present some good prospects for a daylighting connection. The major obstacle to attaining this goal however, is Point Grey Road and the deeply embedded infrastructure that lies beneath it.

To resolve this complication I designed a culvert-bridge, which is seen in the resulting proposed creek channel diagram **(Figure 12)**. This diagram shows my proposed 60 metre channel length from the culvert, which first turns 5 metres east of its former location in Tatlow Park to run perpendicular under Pt. Grey Road into, and through Volunteer Park to its mouth at English Bay. At grade, I propose a connecting pedestrian path across the busy street to allow easier access to and from both parks. Other significant changes to the parks involve

---

[22] Piteau Associates (2000). Restoration of First Creek, Tatlow Park, Vancouver, 2.

widening and stabilizing the entire creek channel to make allowance for increased and continual annual flows. Furthermore, I added a circuitous pedestrian path through Volunteer Park and connected both sides of the proposed creek with a wooden pedestrian bridge, to be designed in the same spirit as those existing in Tatlow Park. The paths within the park lead to a raised, wooden platform lookout (Figure13) which takes advantage of the site's fantastic

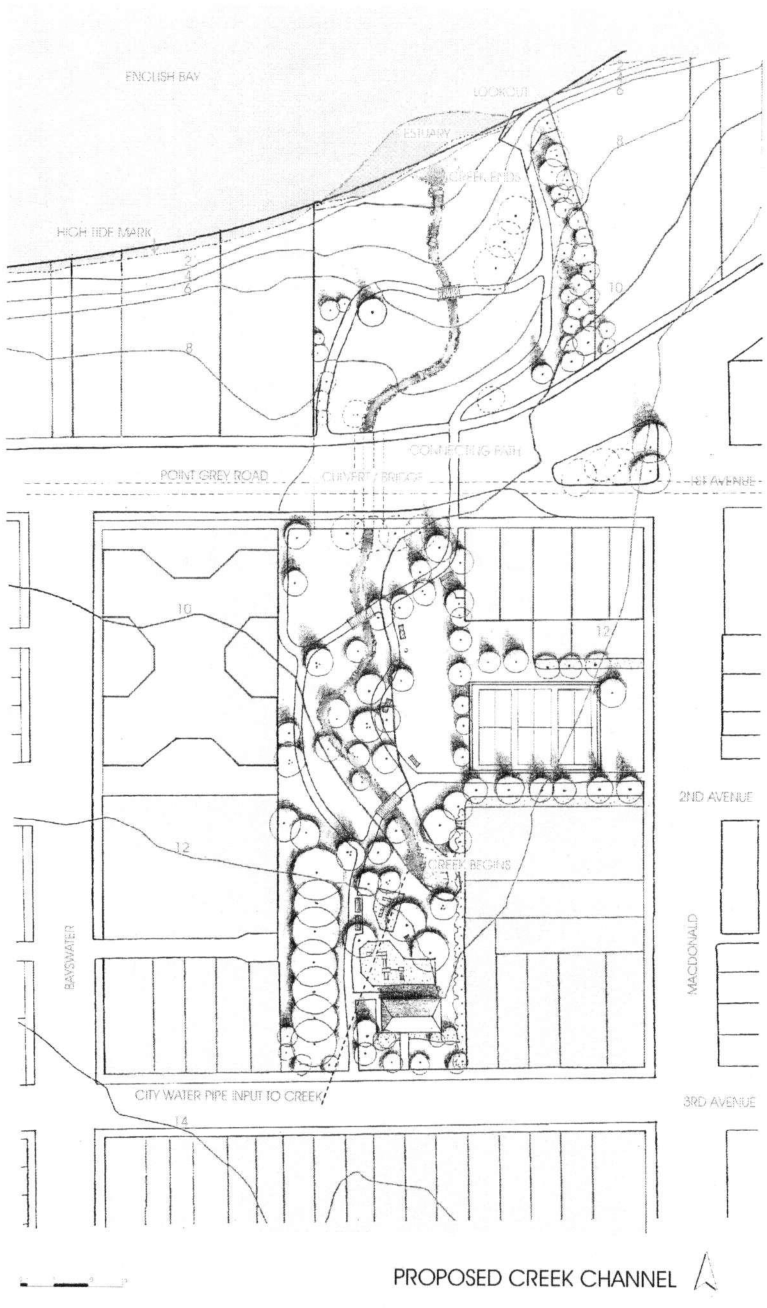


Figure 12

views of downtown Vancouver, the north shore mountains, and the sunset, as well as of the creek mouth and channel. The structure is draped with a native, coastal honeysuckle whose roots, and the roots

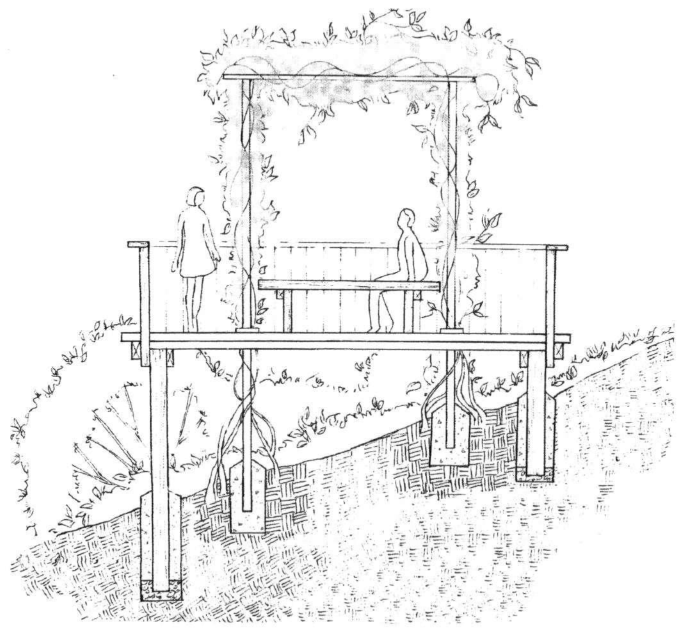
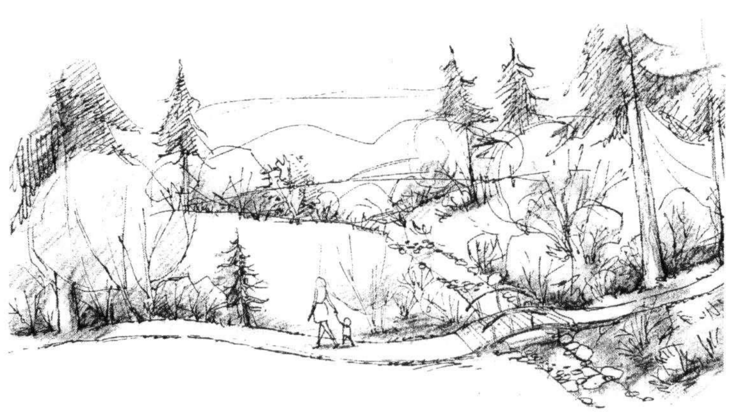


Figure 13 The Lookout

of shrubs planted beneath it, provide extra slope stability for the north-east corner and edge of the park, which will remain steep.

At the creek's mouth I am proposing a space for an estuary, which will provide a transitional edge for salmon as they adjust for the freshwater environment. All of these spaces, including those within Tatlow park, are landscaped with native plants in such a way as to create a specific plant gradation.



This gradation is made up of an overstorey, understorey and groundcover, and not only ensures a thick riparian edge to the creek which functions to deter access by people and dogs, but also creates valuable habitat for birds and other small mammals, creatures and organisms which typically live in and around streams **(Figure 14)**. The continual and growing presence of this flora and fauna helps to maintain a healthy creek and creek environment, which can support thriving and sustained fish populations.

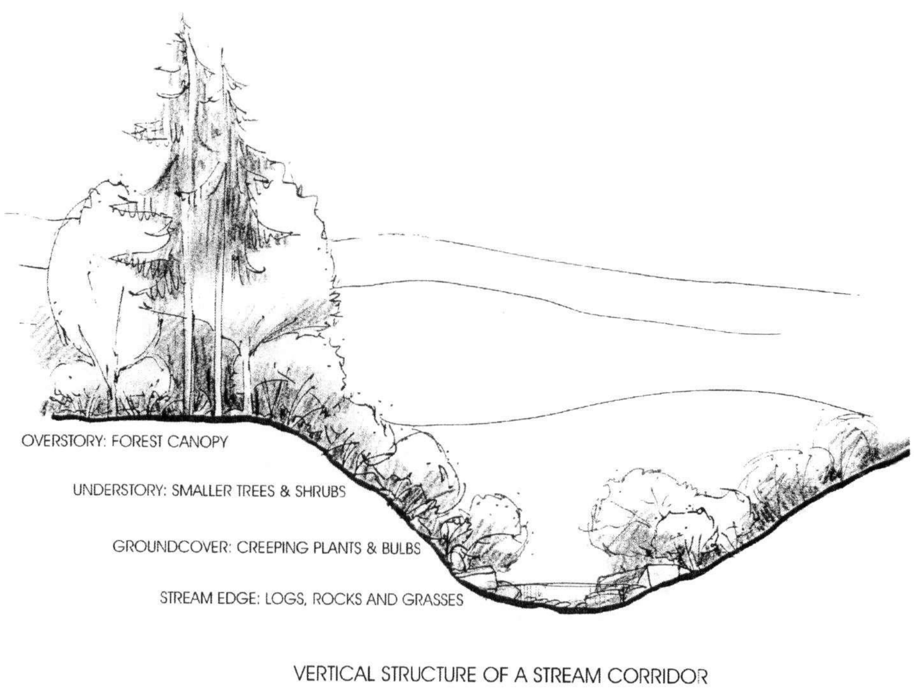
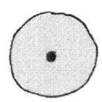


Figure 14

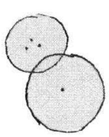
As previously mentioned, the planting plan is based on a native assortment of deciduous and evergreen plants, and include many which were historically present in the area. According to one source, Vancouver was forested with overstories such as Douglas Fir, Cedar and Western Hemlock which towered over 99 metres, and were approximately 1000 years old.[23] These and other plants, many of them berries, combined to form a rich and varied environment which I intend to emulate as much as possible in my design **(Figure 15)**.

OVERSTORY



Evergreen

Western Red Cedar *Thuja plicata*
Douglas Fir *Pseudotsuga menziesii*
Western Hemlock *Tsuga heterophylla*
Pacific Madrone *Arbutus menziesii*
Shore Pine *Pinus contorta var. Contorta*



Deciduous

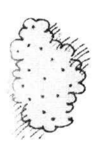
Big Leaf Maple *Acer macrophyllum*
Greene's Mountain Ash *Sorbus scopulina*
Vine Maple *Acer circinatum*
Paper Birch *Betula papyrifera*
Pacific Crabapple *Malus fusca*

GROUNDCOVER

Evergreen

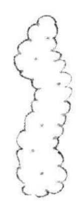
Salal *Gaultheria shallon*
Oregon Grape *Mahonia nervosa*
Kinnickinick *Arctostaphylos uva-ursi*
Western Sword Fern *Polystichum munitum*
Creeping Snowberry *Gaultheria hispidula*
St. John's Wort *Hypericum calycinum*

WETLAND
(To withstand both drought and inundation)



Western Red Alder *Alnus rubra*
Paper Birch *Betula papyrifera*
Redtwig Dogwood *Cornus stolonifera*
Cattail *Typha latifolia*
Common Rush *Juncus effusus*
Dense Sedge *Carex densa*

UNDERSTORY



Evergreen

Pacific Rhododendron *Rhododendron macrophyllum*
Evergreen Huckleberry *Vaccinium ovatum*
Tall Oregon Grape *Mahonia acquifolium*
Silk-Tassel Bush *Garrya elliptica*

Deciduous

Thimbleberry Rubus parviflorus
Salmonberry Rubus chamaemorus
Red Elderberry Sambucus racemosa
Ocean Spray Holodorus discolor
Nootka Rose Rosa nutkana
Pacific Ninebark Physocarpus capitatus
Cascara Rhamnus purshiana
Serviceberry Amelanchier alnifolia
Red-Osier Dogwood Cornus stolonifera
Hardhack Spiraea douglassi ssp. Douglassi
Western Trumpet Honeysuckle Lonicera ciliosa

ESTUARINE

Saltgrass *Distichlis*
Saltwort *Salicornia*
Eelgrass *Zostera marina*
Sweetgale *Myrica gale*
Lyngebye's Sedge *Carex lyngbyei*
Bulrush *Scirpus californicus*
Broad-leaved Cattail *Typha latifolia*

Native Plant List

Figure 15

[23] Macdonald, B. (1992). Vancouver: A Visual History. Vancouver, Talonbooks, 10.

2.2 Creek Channel

The creek channel depth and width is based upon calculations for a 5-year storm, with a maximum flow velocity of $1.80m^3$/second.[24] These numbers, however, represent the maximum velocity from an immediate stormwater discharge from the engineered catchment systems I and II in figure 4. This refers to water coming *directly* from the stormwater pipe to the creek. With my proposed green infrastructure design, however, such a sudden velocity of water would not be attained since stormwater must first infiltrate through the ground

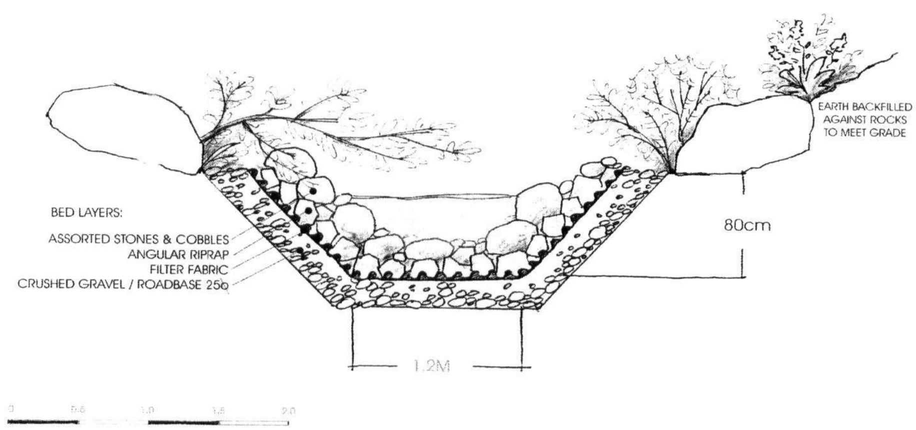


Figure 16 Creek Channel Cross-section

and gradually reach the creek by way of interflow. My decision to use these numbers is therefore a "safe" target maximum based on predicted peak flows for a direct water discharge to the creek.

[24] Aaron Grill, City of Vancouver Engineering, personal communication, June 5, 2003.

Consequently, my proposed creek channel has a 1.2 metre base width and 0.80 metre bankfull depth **(Figures 16, 17)**.

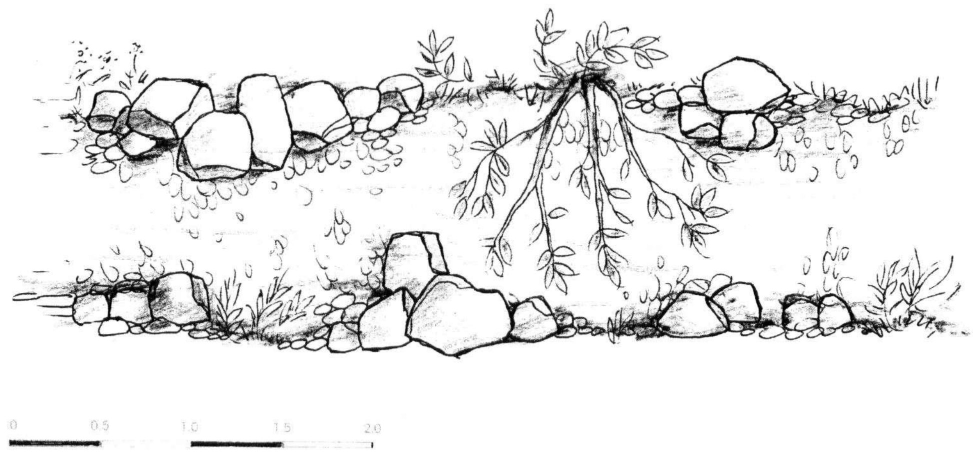


Figure 17 Creek Channel Plan

Moreover, in order to protect against erosion of the banks where the creek design obliges the slope to be steep, I have suggested two methods of slope stabilization; live cuttings and live cribwall **(Figure 18)**.

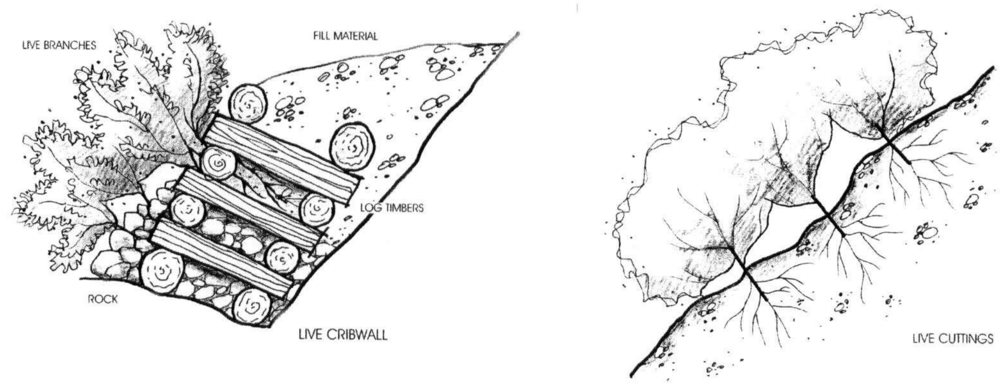


Figure 18 Slope stabilization techniques

Another way of strengthening a terraced bank floodplain is by constructing a "toe" using rocks and cobbles **(Figure 19)**, or, if the slope isn't too steep (<50%), then stability can be accomplished simply by using rocks and logs in conjunction with various plant layers.

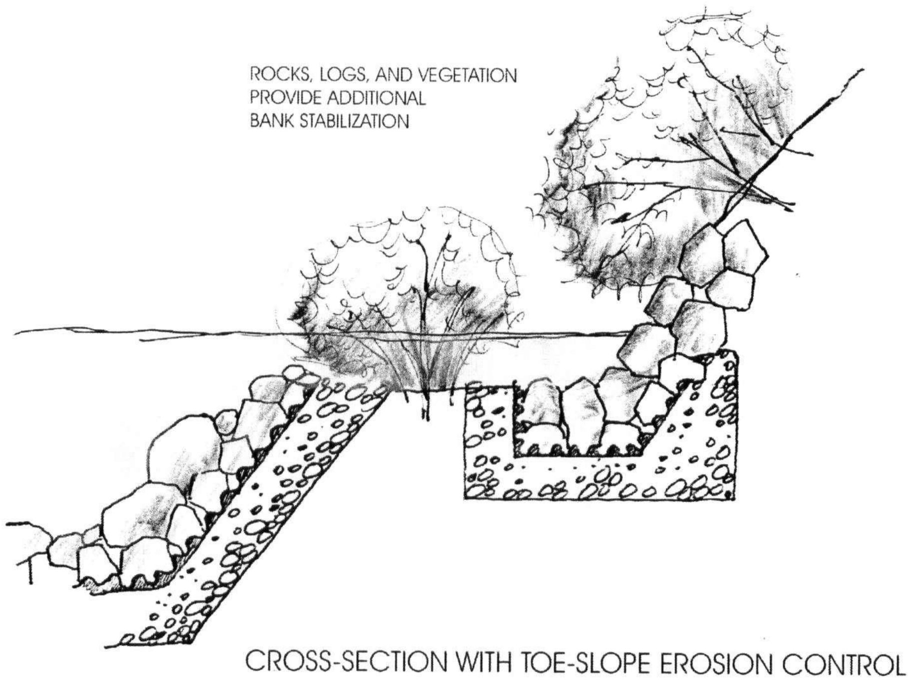


Figure 19

In an effort to keep the creek channel below a 10% gradient through the softer sedimentary soil layers in Volunteer Park, I have designed a series of 4 metre long weirs throughout the

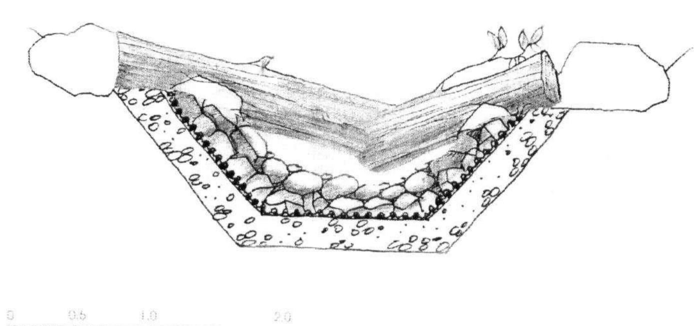


Figure 20 Log weir: cross-section

channel. These could be fashioned of rocks or logs, and function to keep water velocity in check (Figures 20, 21).

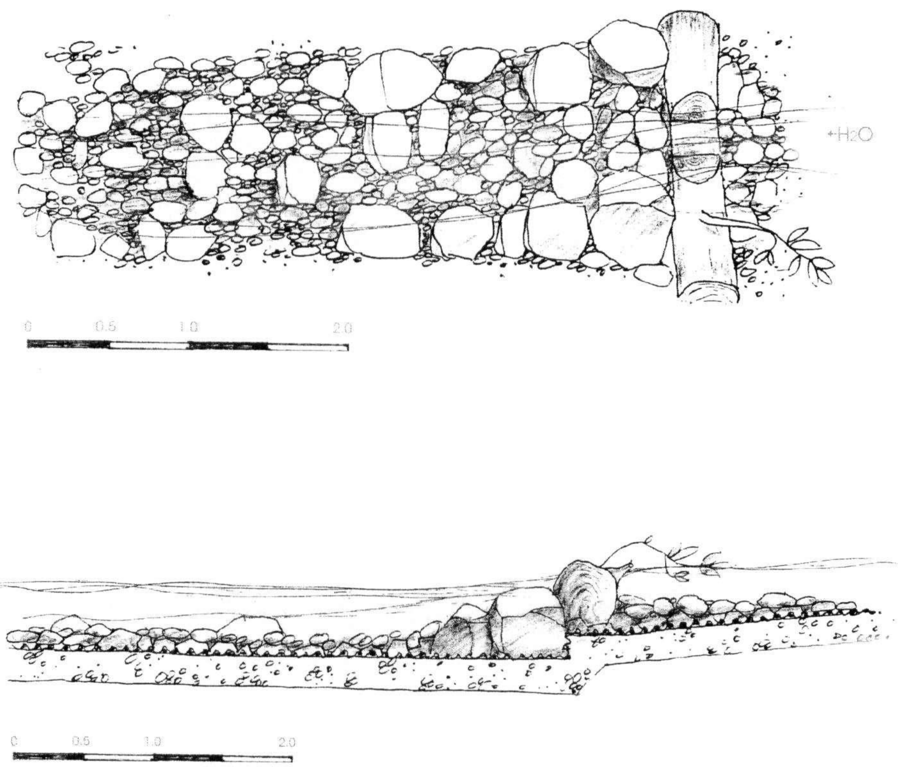


Figure 21 Log weir: Plan, above and Long Profile, below

In order for the creek to successfully cross from Tatlow into Volunteer Park, it needed to cross under Pt. Grey Road, and I had to design around the existing infrastructure beneath it. Under the typical 30 cm road base, there lies a 60 cm deep utilities box with water, gas and hydro pipes. Below that is the main GVRD combined sewer-water trunk pipe, 1.8 metres in diameter (Figure 22).

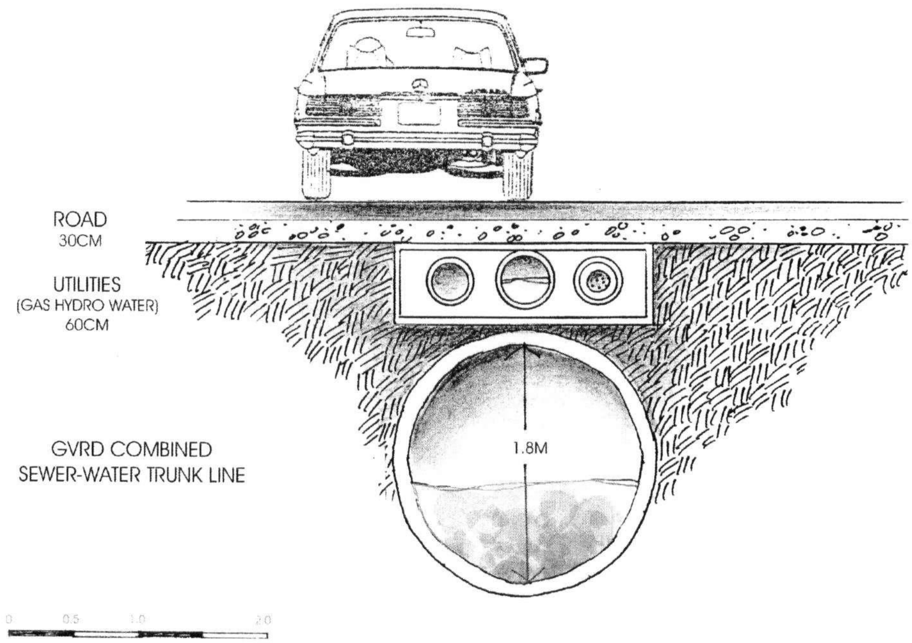


Figure 22 Showing the existing pipes beneath Pt. Grey Road

Accordingly, I am proposing a concrete T-shaped culvert which functions as a suitable bridge over the creek while simultaneously suspending the hefty infrastructure above it. The culvert would be integrated with my green infrastructure plan by including swales at both sides which filter stormwater runoff before allowing it to enter into the creek by way of attractive spouts on either side of the structure **(Figures 23-25).**

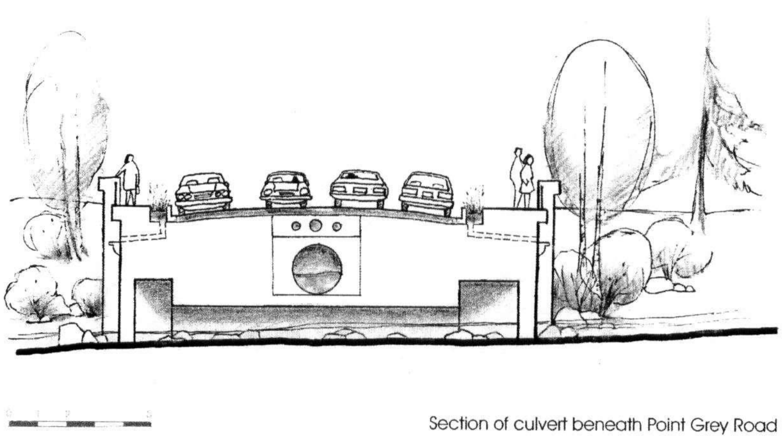


Figure 23

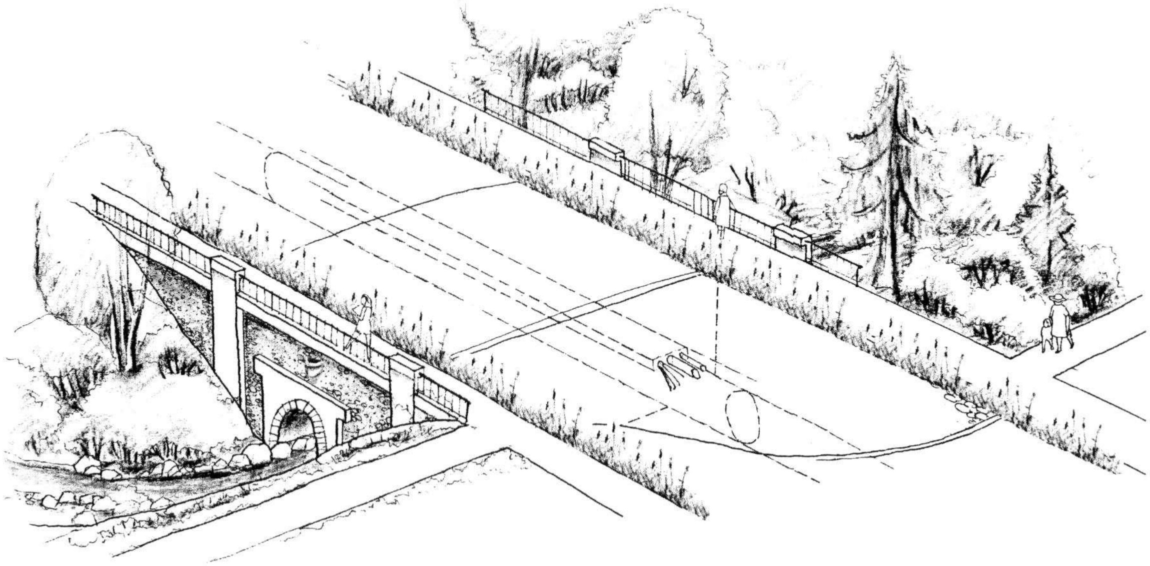


Figure 24 Perspective view of proposed culvert/bridge with biofiltration swales along Point Grey Road

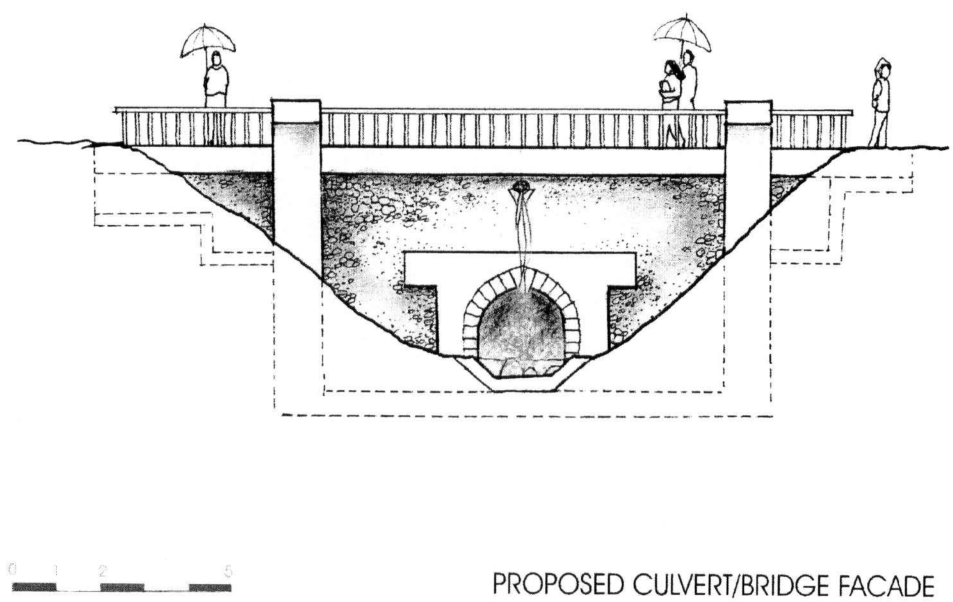
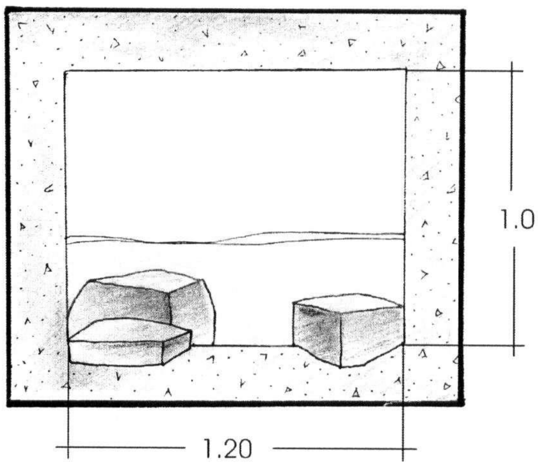
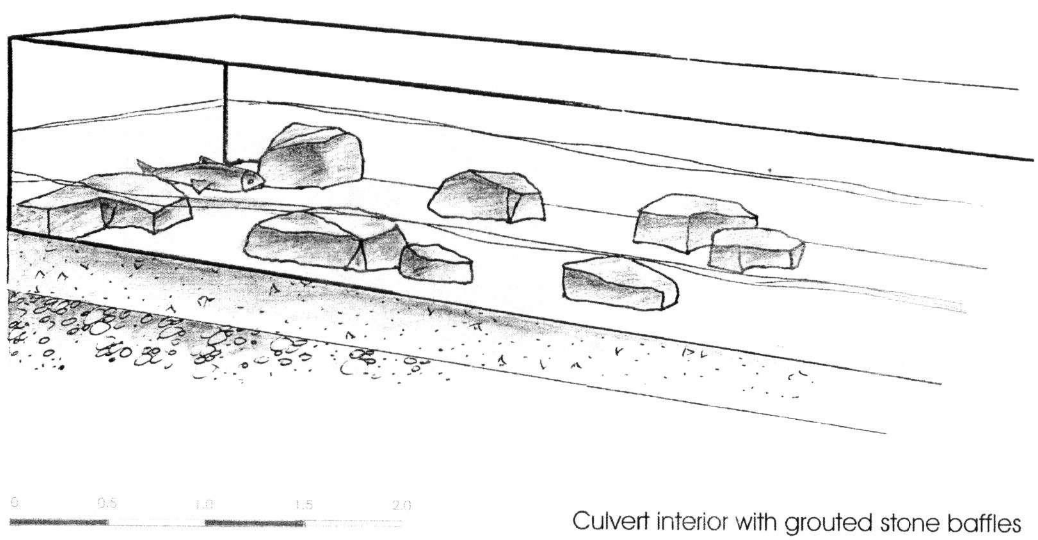


Figure 25

The dimensions of the culvert itself has the same base width as the creek channel, and a height of 1 metre to allow for light and air



Culvert dimensions



Culvert interior with grouted stone baffles

Figure 26

penetration **(Figure 26)**. Furthermore, the culvert has stone baffles grouted in place on its base, to prevent the increased velocity which can occur in smooth channels.

The culvert can hence be seen situated in its overall context, in the existing and proposed land profile **(Figure 27)**. As the existing Tatlow Creek is, on average, a depth of 3 metres below top of bank, the change in depth to accommodate the culvert beneath the road utilities was not of consequence. As the land profile in figure 27 shows, the most significant change occurs to the grading within Volunteer Park, which is intended to minimize the distance between the top of the proposed bank and the creek, as well as to provide for a gently sloping channel gradient. These contour changes are evident in figures 28 and 29.

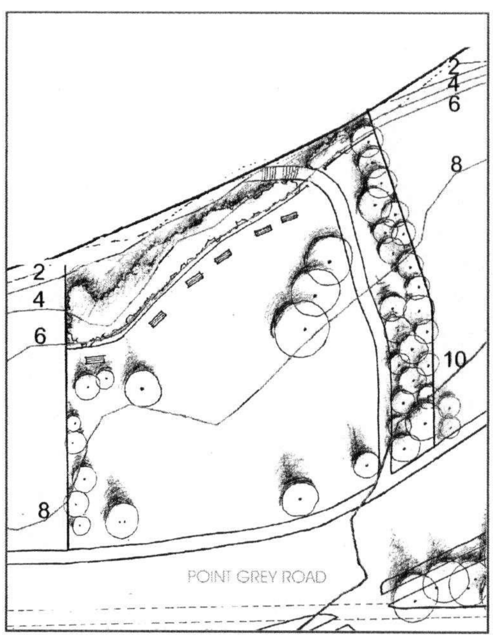


Figure 28 Existing contours

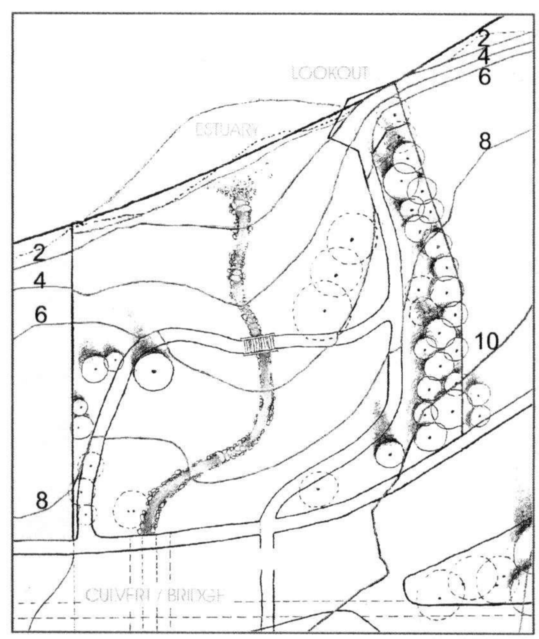


Figure 29 Proposed contours and channel

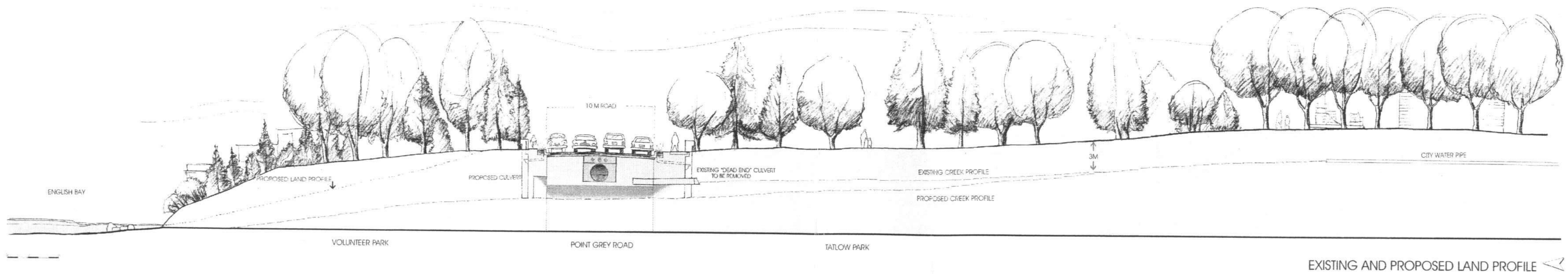


Figure 27

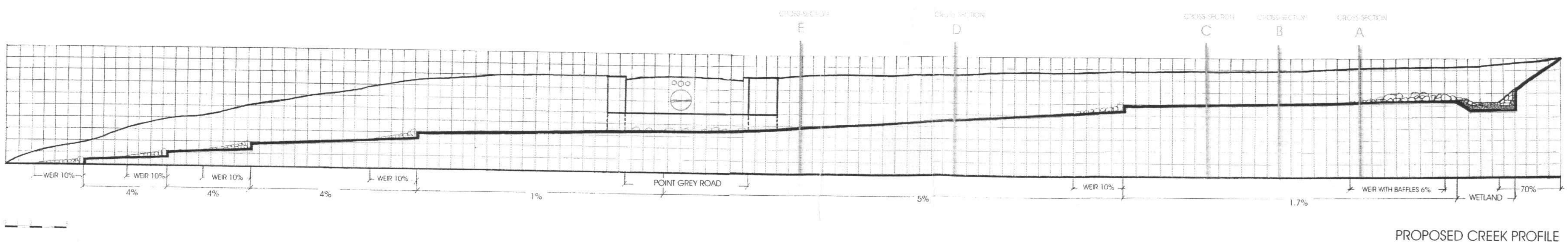


Figure 30

As noted in figure 29 by the dashed circles, the removal of existing trees was required. Superfluous earth produced by the land grading process could then be used to build up the sides of the existing creek to conform to the addition of the new creek channel, or used in urban agriculture projects and community gardens in the neighbourhood.

The proposed creek profile shows the creek gradient and 7 weirs suggested along its length **(Figure 30)**. At the beginning of the creek in Tatlow Park I have proposed a wetland which traps and filters receiving water before slowly draining it into the creek. Such water could come from the roofs of nearby residences, sheet-flow from the adjacent tennis courts, and the constantly infiltrating water from roadside swales.

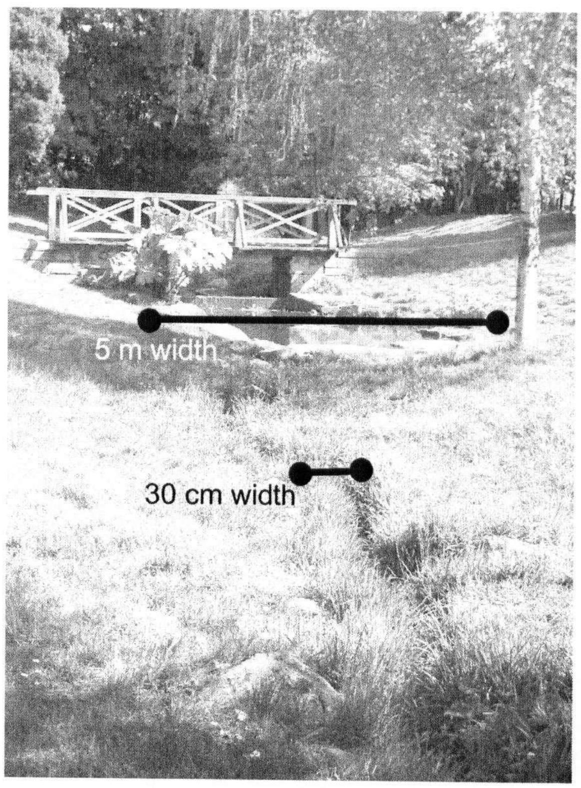


Figure 31 Irregular creek channel

Since Tatlow Creek is not a normally functioning stream, its channel is likewise not representative of such. As it currently lies, the channel widens from a sprawling 5 metres, down to a puny, grass covered 30 cm with depths from a maximum 29 cm to 9 cm, respectively **(Figure 31)**. The existing channel hence requires regularization to support a stable flow and adequate depth, and to allow for fish passage.

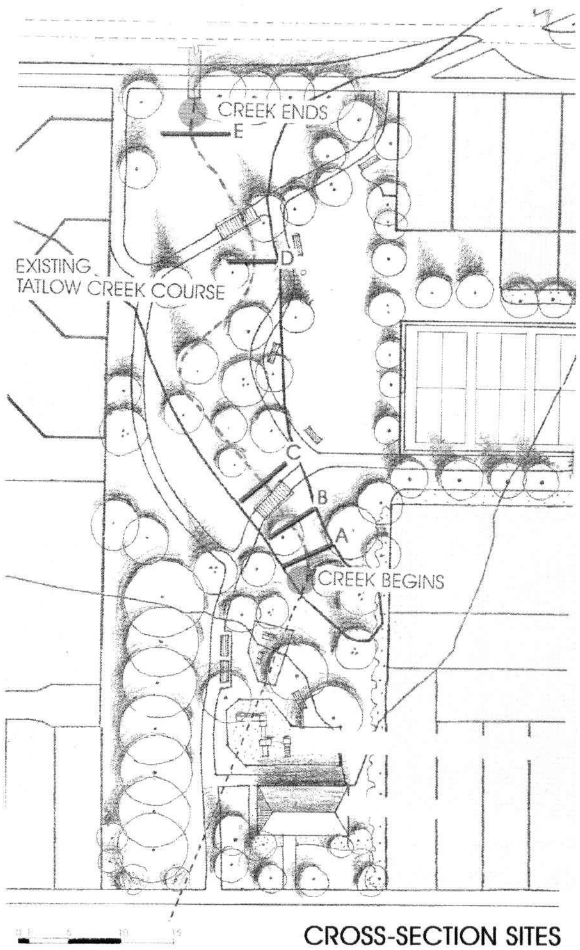
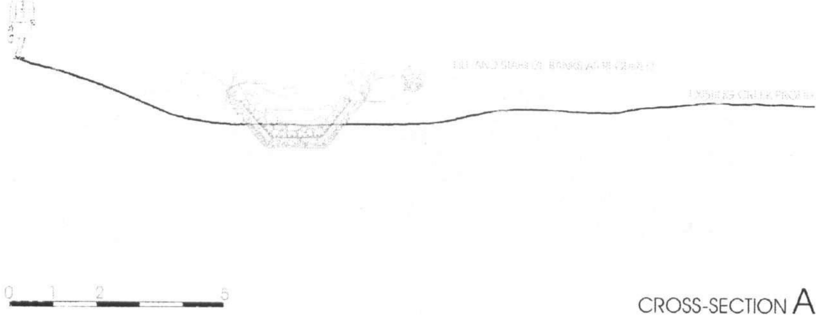
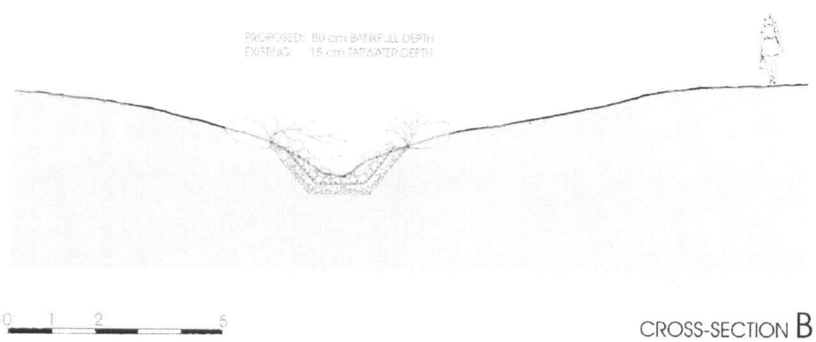


Figure 32

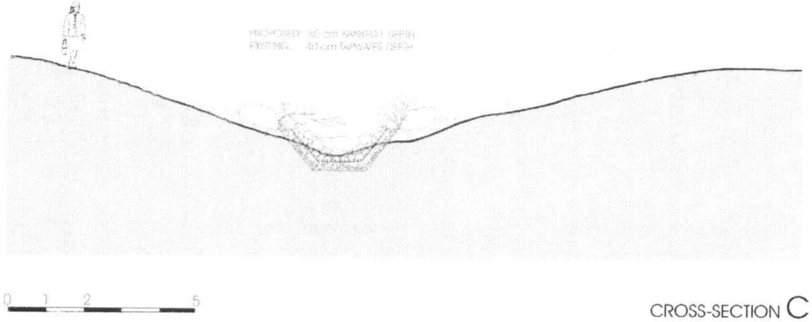
I then measured cross-sections A to E of the creek in Tatlow Park to establish a more accurate depiction of the existing profile. Sections A to E represent these profiles as they could be, with my suggested channel design superimposed on them **(Figure 32 and cross sections A-E)**.



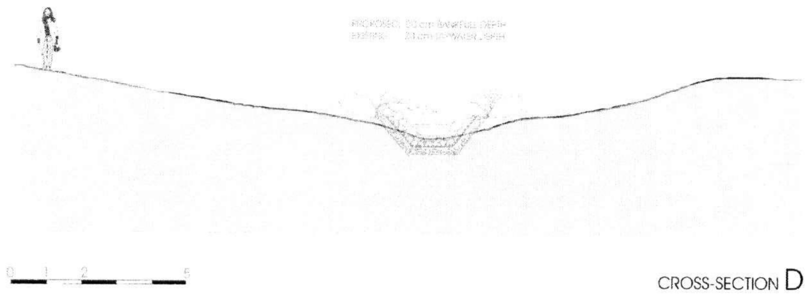
CROSS-SECTION A



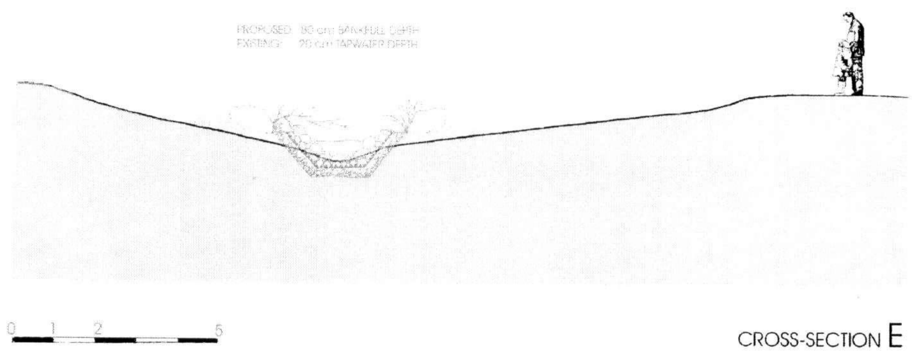
CROSS-SECTION B



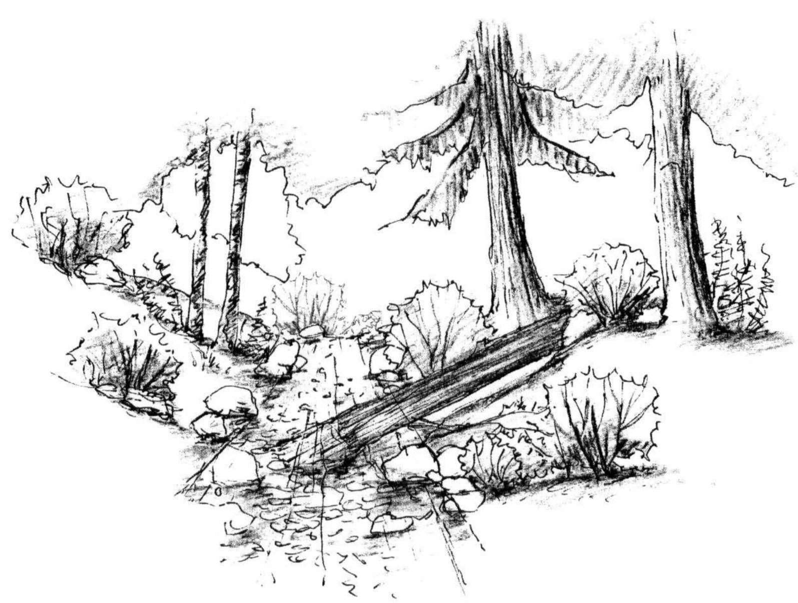
CROSS-SECTION C



CROSS-SECTION D



CROSS-SECTION E



Up to this point, I have modified and connected the existing creek channel across Point Grey Road and designed an adequate stream channel and floodplain appropriate to the site conditions and 5-year stormwater volumes. I have suggested a suitable riparian environment for the proposed and existing creek channel and have initiated the foundation for gradual design transformations which would turn the existing "hard, impervious and grey" urban infrastructure into a "soft, pervious and green" infrastructure, which would subsequently re-charge the creek. Figure 33 is the master plan which illustrates these changes in totality.

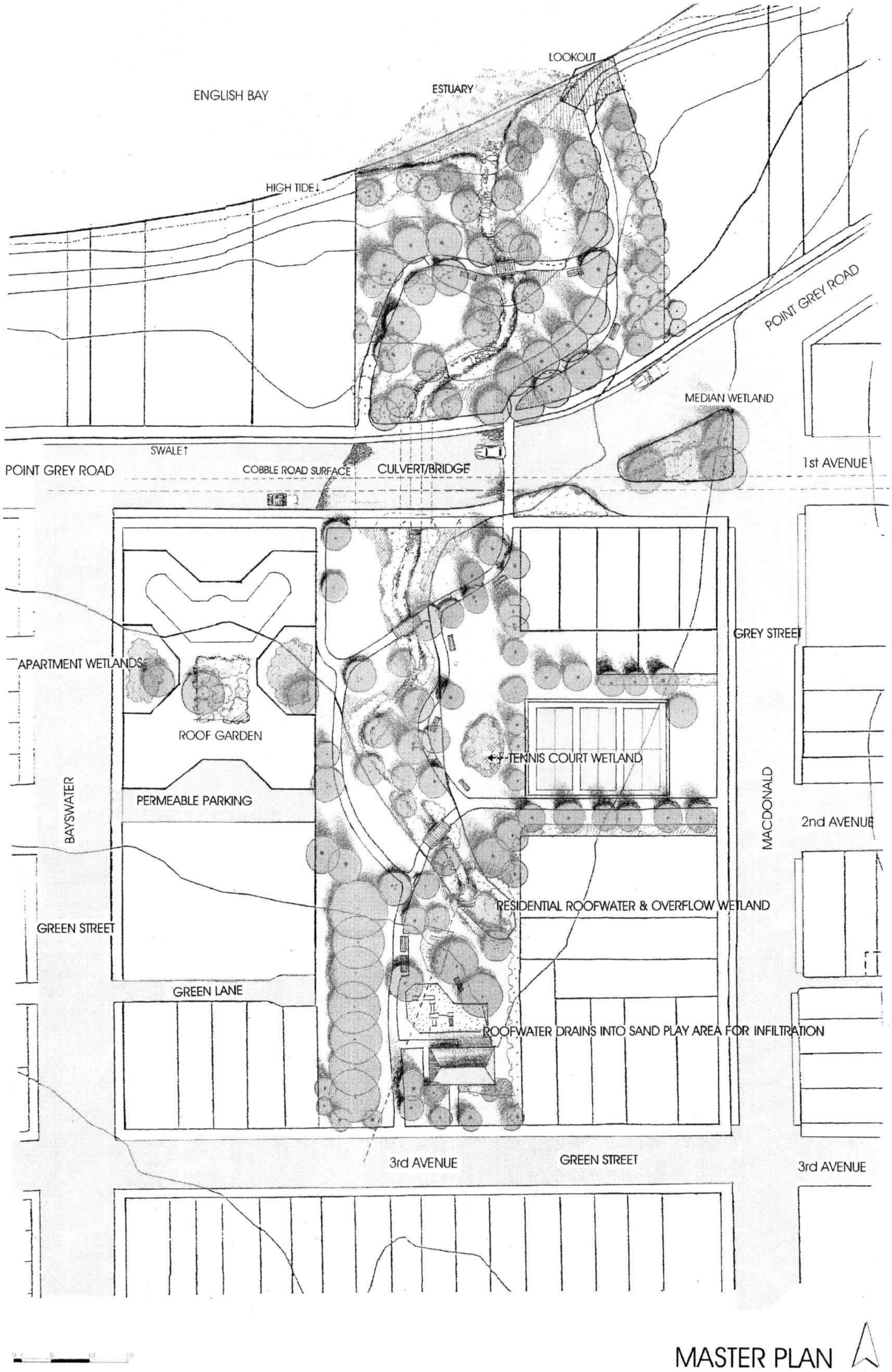

ENGLISH BAY
ESTUARY
LOOKOUT
HIGH TIDE
POINT GREY ROAD
MEDIAN WETLAND
SWALE
POINT GREY ROAD
COBBLE ROAD SURFACE
CULVERT/BRIDGE
1st AVENUE
GREY STREET
APARTMENT WETLANDS
ROOF GARDEN
TENNIS COURT WETLAND
BAYSWATER
PERMEABLE PARKING
MACDONALD
2nd AVENUE
RESIDENTIAL ROOFWATER & OVERFLOW WETLAND
GREEN STREET
GREEN LANE
ROOFWATER DRAINS INTO SAND PLAY AREA FOR INFILTRATION
3rd AVENUE
GREEN STREET
3rd AVENUE
MASTER PLAN

Figure 33

The following sections (A-F) illustrate the proposed character and landform of the site and correspond to the marked locations on the master plan area shown in figure 34.

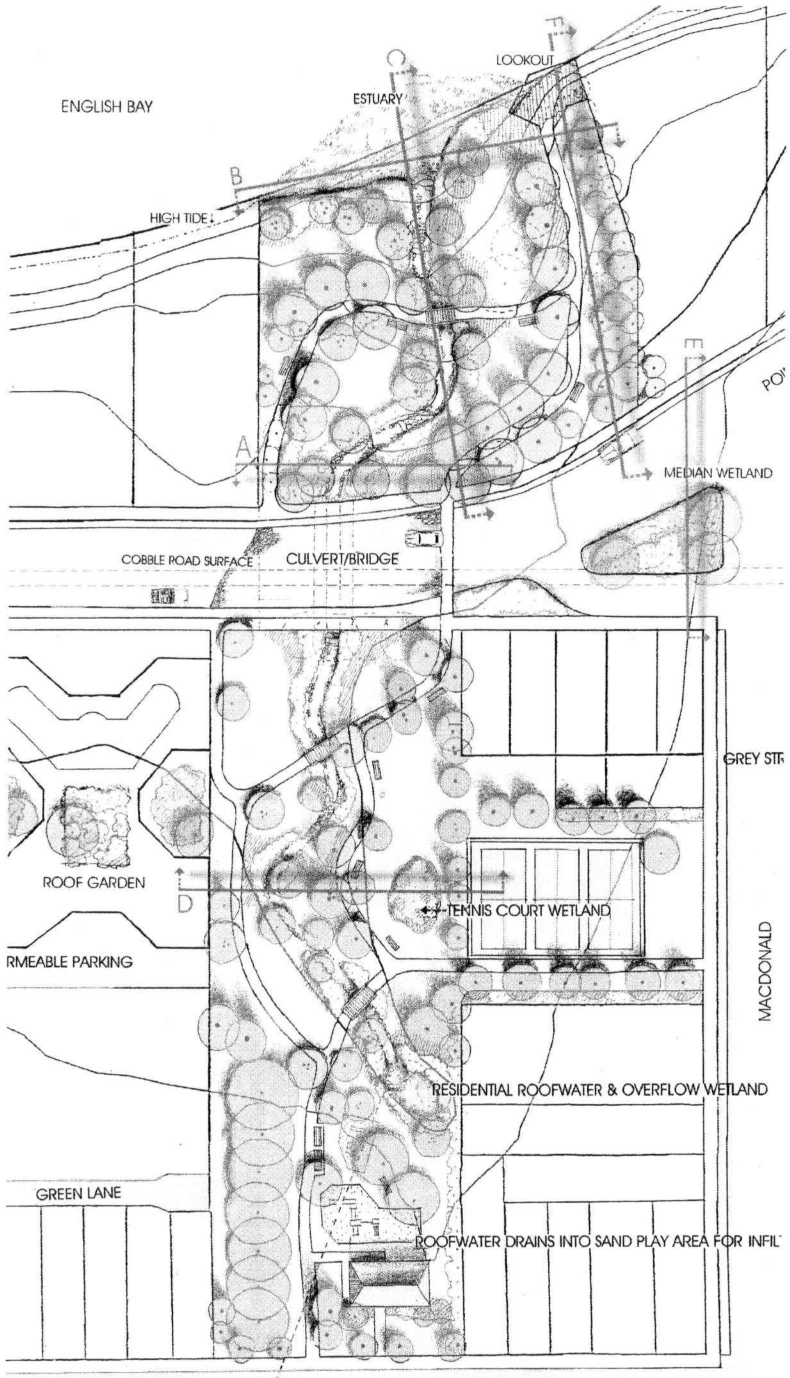
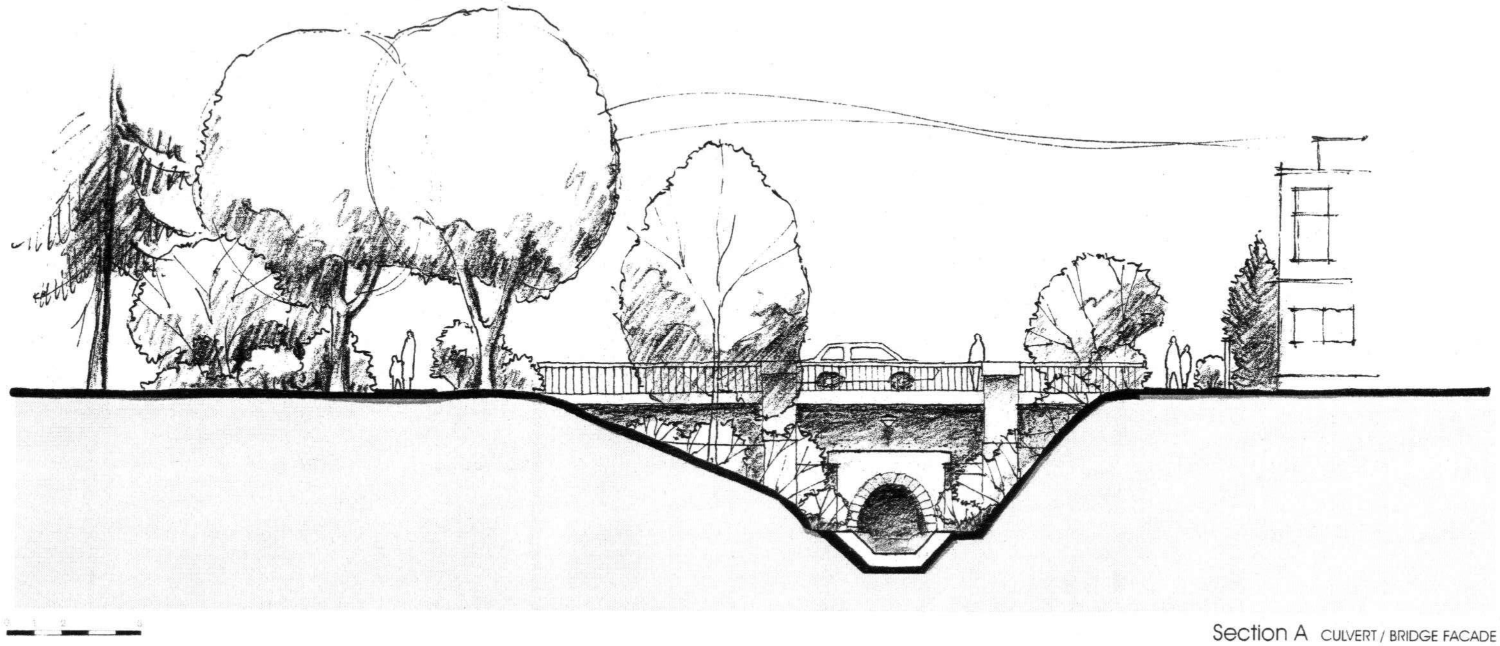
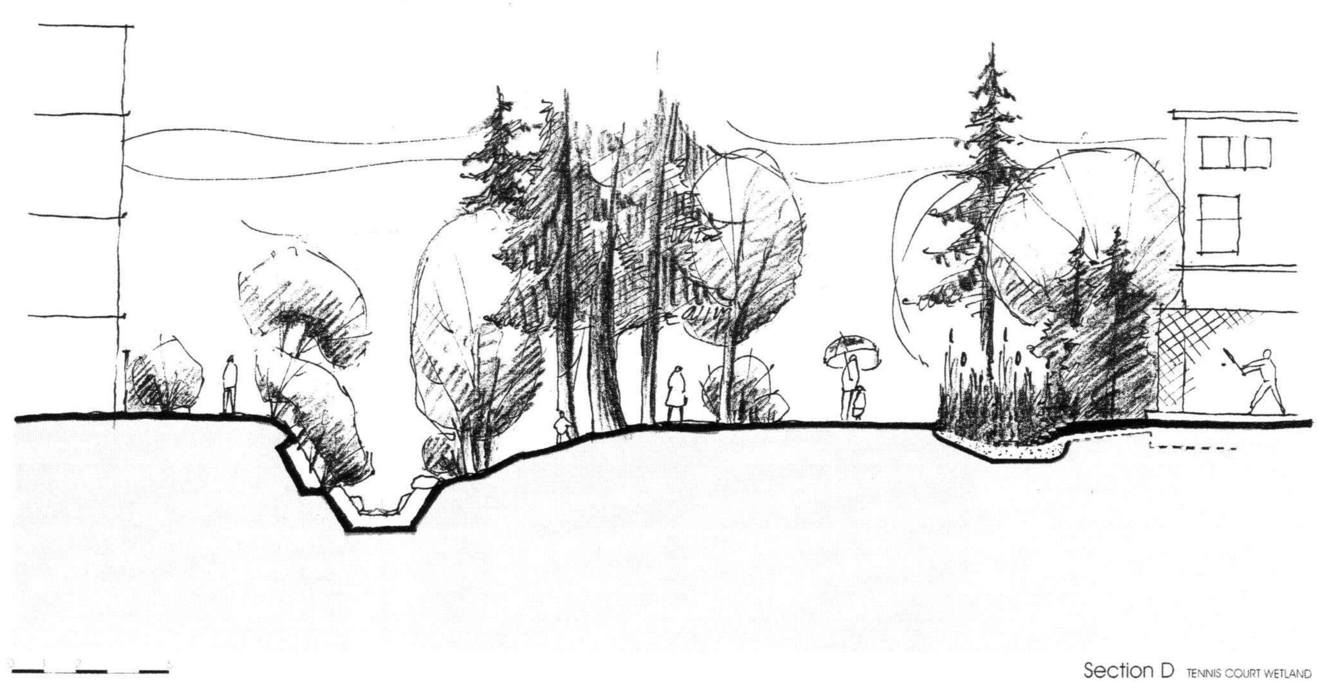


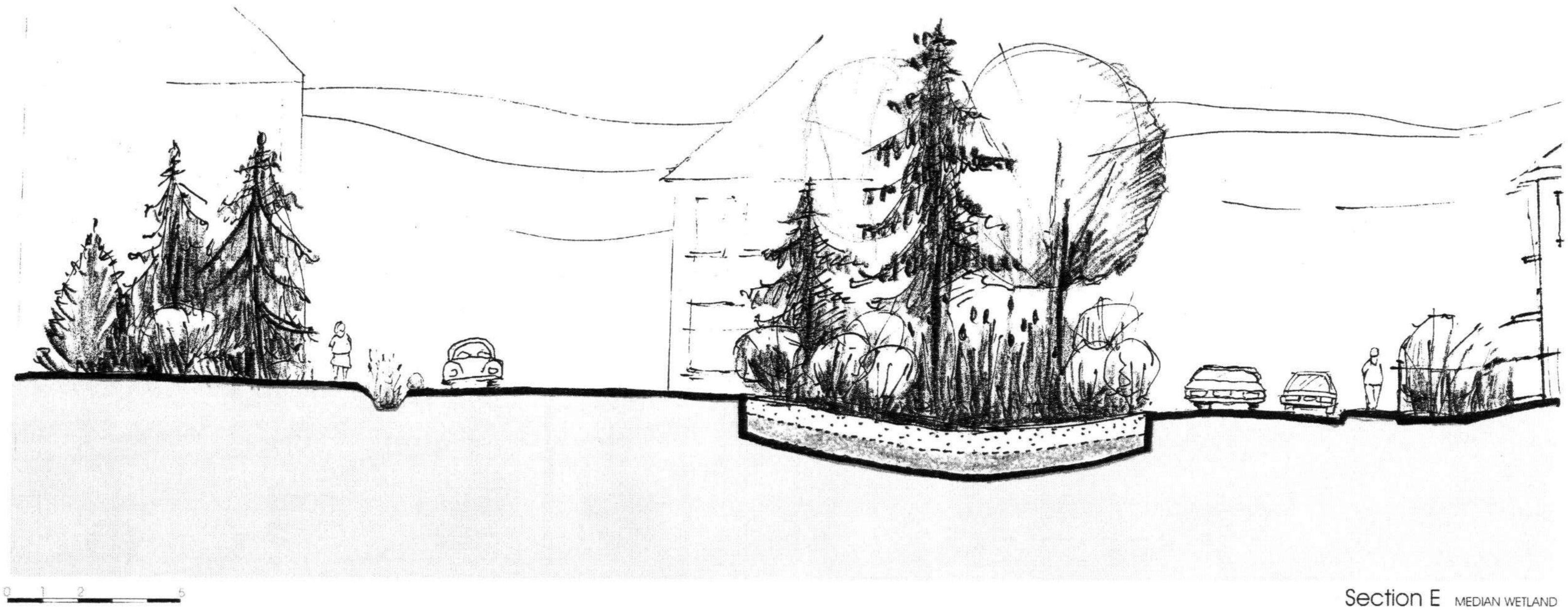
Figure 34



Section A CULVERT / BRIDGE FACADE



Section D TENNIS COURT WETLAND



Section E MEDIAN WETLAND

2.3 Green-Grey Grid

Until now I've begun to suggest designs for realizing a creek base-flow using swales and wetlands. The master plan shows additional changes which include vegetated, grass or gravel swales on every road, and a "green-grey grid" street network which forms the basis of the green infrastructure system. This endeavour instigates a long-term watershed-to-region strategy for sustaining not only our creeks but a healthy hydrological system, water reservoir, ecology and society.

Sustainable fish habitats are dependent on functional watershed processes. Certainly, "If fish could talk and we asked them, "Which of our engineering techniques have had the most negative impact on fish habitat?", my guess is that the answer would be paving"[25]

Indeed the green-grey grid is an attempt to mitigate, and over time eliminate, the harmful effects that paving causes on the watershed and ecology. The network is comprised of a grid of streets; some green, some grey as the name suggests. Green streets contain the following characteristics: they are 100% permeable; they are narrower than grey streets, pedestrian oriented and as such vehicle access (with the

---

[25] Bomford, J. (1997). Can Fish Habitat Be Engineered? Urban Stream Protection, Restoration and Stewardship in the Pacific Northwest: Are we achieving desired results?, Douglas College, Quadra Planning Consultants, Ltd, 63.

exception of emergency vehicles) is limited or denied;[26] and they are highly vegetated. Because of these particular qualities, green streets are generally, but not exclusively, residential streets and lanes. Grey streets, on the other hand are the busier arterial and collector streets which permit vehicle access, and are permeable in that stormwater runoff is directed to swales and infiltration strips along both sides of the streets. For streets where construction (such as pipe-separation) is not taking place and curbs cannot be readily eliminated without excessive cost, such streets could be retrofitted with curb inserts which permit runoff to enter the linear swales **(Figure 35)**.

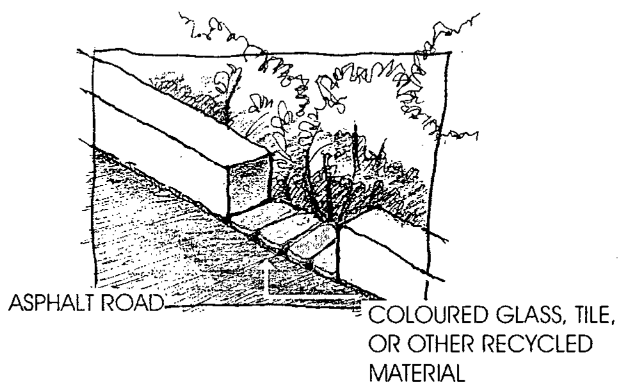


Figure 35

Mutually, these green and grey streets aim to infiltrate all of the stormwater which falls onto paving, or any other road surface. Taken together with residential and commercial stormwater re-use, in the form of roof gardens or cisterns for instance, or re-direction to nearby wetland pockets and swales, 90 to 100% of all stormwater can be infiltrated and

---

[26] The Netherlands' *woonerf* is an example of such a narrow, generally residential, pedestrian-oriented street, but may not be permeable.

in this way can subsequently re-charge the baseflow not only in Tatlow Creek, but in other daylighted urban streams as well. Such a network would be phased in over time, and on a regional scale connected to commercial and industrial districts and other, larger greenspaces and greenways in and around parks, schools, hospitals and the like. Figure 36 shows a 10-year, 25-year and 100-year recommended phase-in plan for the grid, while figure 37 proposes an example green-grey street pattern within the Tatlow Creek watershed and its corresponding street section. Figure 38 then provides detailed examples of each proposed street typology.

As previously mentioned, my designs also include retrofitting existing engineered infrastructure such as curbs and catch-basins to enhance the green-grey grid. As my design proposes a network of perforated pipes which allow rainwater immediate infiltration capability, the stormwater runoff has 3 options: 1. going straight into the ground 2. going into a perforated pipe which leads to a wetland or other biofiltration pocket, or 3. going through a perforated pipe into a catch-basin which is specifically designed for filtering first-flush runoff; that which occurs in the first 1-1.5 hours of a storm, and which contains the highest concentrations of pollutants like oils, soaps, metals, fertilizers, pesticides and sediments.[27]

After filtering through the catch-basin, the water would then carry on through perforated pipes to infiltrate into the ground to a creek or wetland **(Figure 39)**. Such pipes are to be located under roadside swales and along the edges of impervious areas which cannot otherwise be made permeable, with drainage holes that would allow a slow drip of water to go through, but not a fast flow in a large storm, thus avoiding contaminants from leaking through **(Figure 40)**.

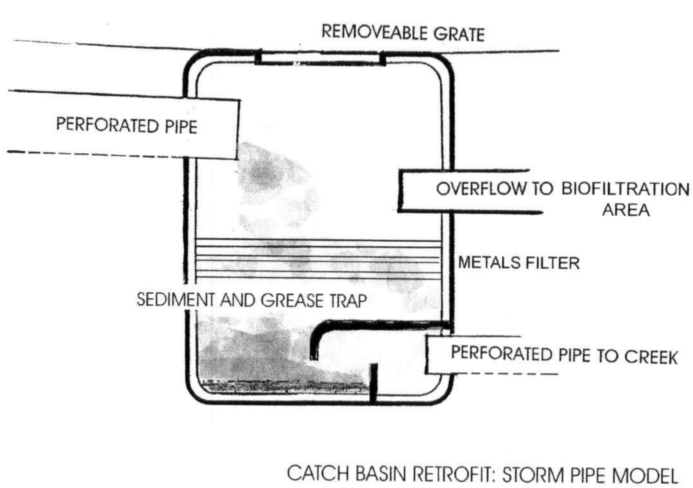


Figure 39

(continued on page 54)

[27] Kulzer, L. R. (1997). Stormwater Quality Control. Urban Stream Protection, Restoration and Stewardship in the Pacific Northwest: Are we achieving desired results?, Douglas College, New Westminster, Quadra Planning Consultants Ltd, 49.

Figure 36 A suggested phase-in plan for a green-grey street grid

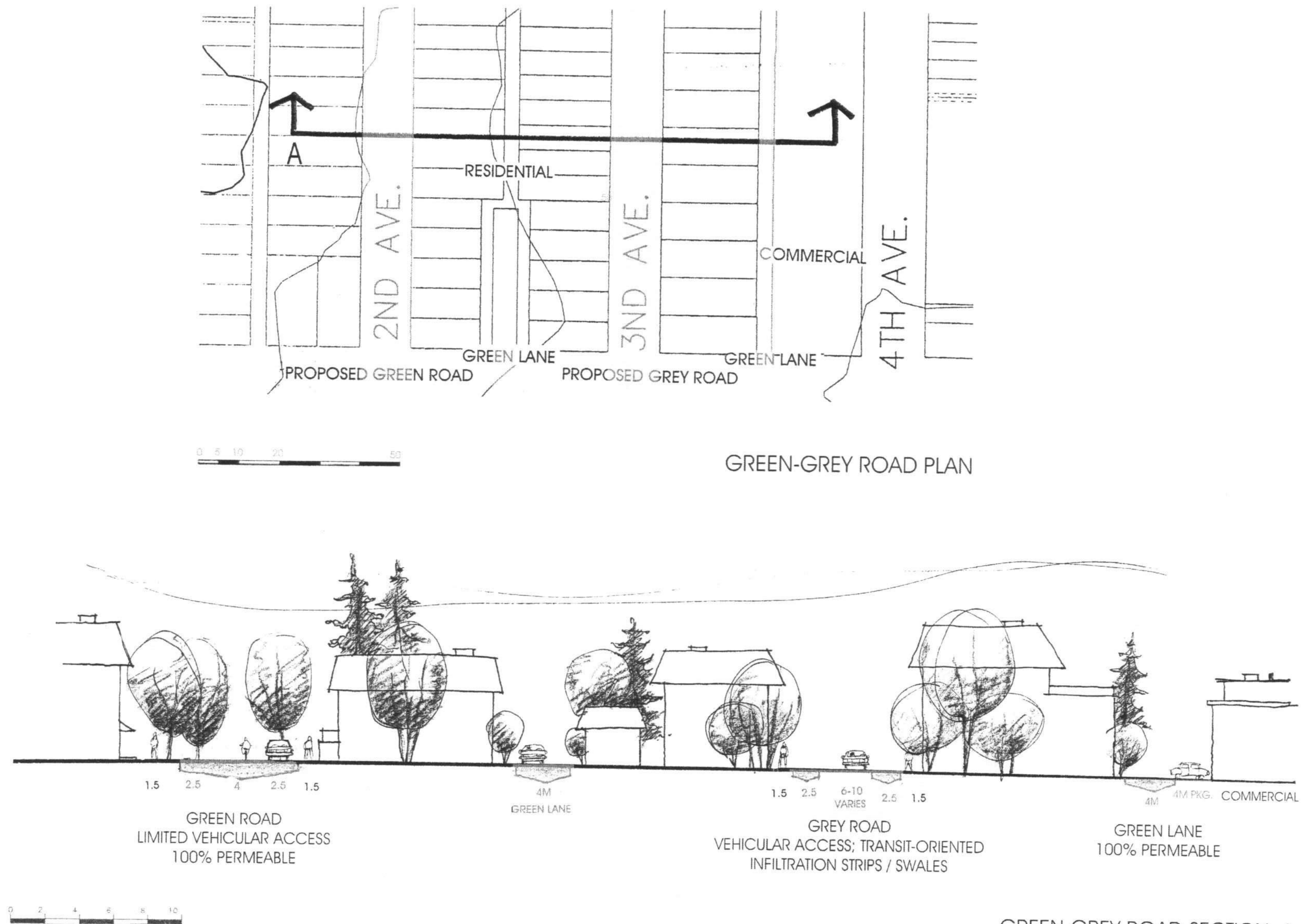
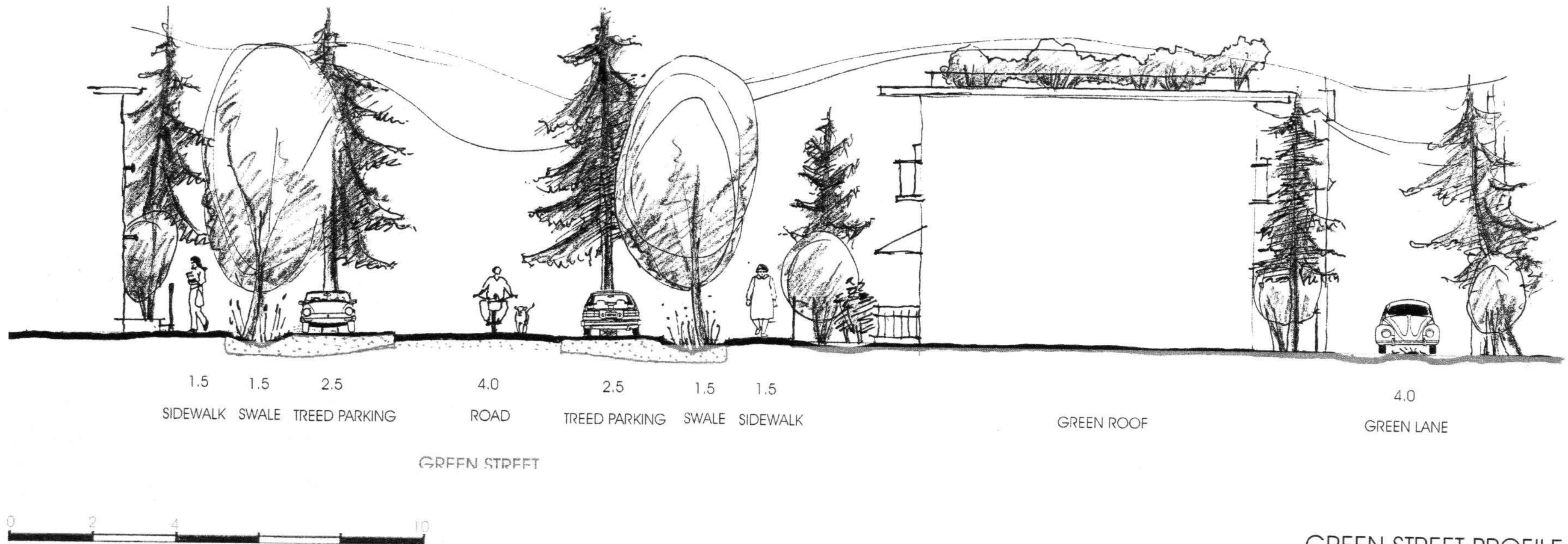
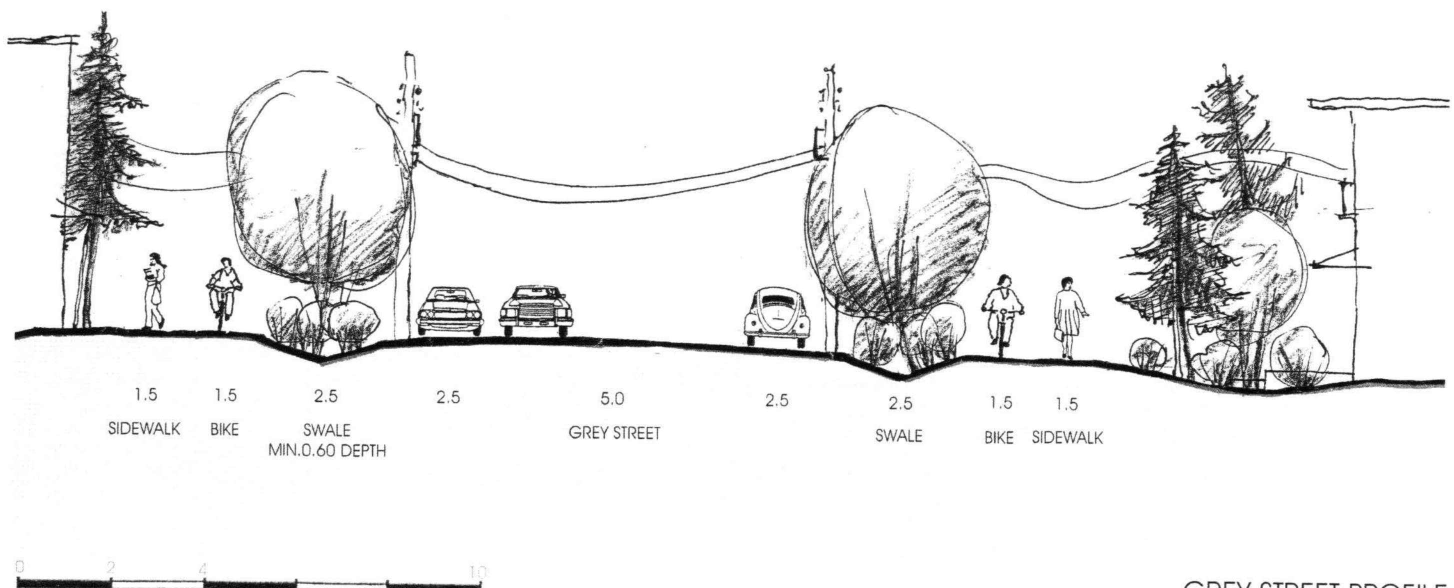


Figure 37 Plan and corresponding section of a green-grey grid pattern



GREEN STREET PROFILE



GREY STREET PROFILE

Figure 38

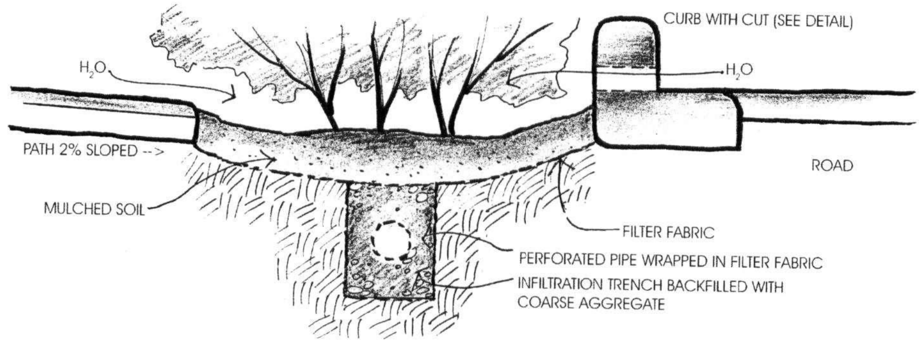


Figure 40

Implementing such a broad-scale restructuring in a developed urban context is no doubt a long-term strategy.

2.4 Concluding Remarks

In addition to the benefits I have previously mentioned, executing the green-grey grid scheme and allowing creeks to channel stormwater would mean a long term cost savings, even though the initial cost of daylighting the creek would be large; at least $600 per metre.[28] And catch-basin retrofits and maintenance may prove to be costly. But in the long term, these costs would be subsidized by other savings. Simply having stormwater uselessly treated in the Iona Island Wastewater Treatment Plant, only to have it pumped out into English Bay, is a cost of approximately $70 000 per cubic foot per

---

[28] SFU (n/d). A Strategic Concept Plan for A Model Sustainable Community in South-East False Creek, Simon Fraser University's Geography 449 class: Environmental Processes and Urban Development.

http://www.sfu.ca/cedc/students/geogclass/grnap37.htm year.[29]Furthermore, the GVRD would save an additional amount from superfluous tap water which runs through Tatlow Creek during the summer months. The cost of water in 2003 is a flat rate of $271.00 per year for single family dwellings, and the metered rate for multi-family residential, industrial or commercial customers is approximately 46.3 cents per cubic meter.[30] The re-use of water using cisterns and other means of storage could save money to these groups as well.

Moreover, the cost to the city, and thus to the taxpayer, for laying water pipe infrastructure is approximately $150.00 per linear metre.[31] This cost however does not reflect the additional fees for labour and materials such as asphalt and fuel. Additionally, further costs are saved since green roads do not require re-paving or considerable maintenance, and even more money would be saved by not constructing curbs.

Perhaps needless to note given the location of the creek, but as a result of the enhanced aesthetic and recreational nature of the proposed site, property values would rise in the area, and taxes would decrease as infrastructure maintenance costs would be lowered.

---

[29] Ibid.

[30] Vancouver Engineering Water Rates: Cost of Water 2003. http://www.city.vancouver.bc.ca/engsvcs/watersewers/water/rates.htm

[31] Condon, P. (2003). Green Municipal Engineering for Sustainable Communities, http://www.sustainable-communities.agsci.ubc.ca/bulletins/municipal_engineer_article.pdf.

Further, because landscaping would be carried out to emulate what would be found in a regional native forest setting, the otherwise high maintenance costs for lawn-mowing and applying fertilizers and pesticides would be reduced, or eliminated.

In all, these costs add up to a significant amount which should not be overlooked when assessing the true value of daylighting creeks and applying green infrastructure designs.

Throughout my thesis I have intended my designs to suggest an overall vision for an urban environment, in which the preservation of water and the significance of creek daylighting is central. I hope that I have achieved my design goal and objectives, designed an integrated and convincing system which not only revitalizes out hydrological and ecological systems, but also implements successful measures which will sustain them in their complex, densifying and transforming urban context.

BIBLIOGRAPHY

Bomford, J. (1997). Can Fish Habitat Be Engineered? Urban Stream Protection, Restoration and Stewardship in the Pacific Northwest: Are we achieving desired results?, Douglas College, Quadra Planning Consultants, Ltd.

CH2MHILL (2002). Effectiveness of Stormwater Source Control. Vancouver, Greater Vancouver Sewerage & Drainage District.

Chilibeck, B. (1993). Land Development Guidelines for the Protection of Aquatic Habitat, Ministry of Environment, Lands and Parks, Integrated Management Branch.

City of Vancouver (2003). Broad City Initiatives, http://www.city.vancouver.bc.ca/sustainability/initiatives.htm.

Condon, P. (2000). Amble Greene, District of Surrey, BC Alternative Stormwater Management Systems: Technical Bulletin. Vancouver, The James Taylor Chair in Landscape & Liveable Environments.

Condon, P. (2003). Green Municipal Engineering for Sustainable Communities, http://www.sustainablecommunities.agsci.ubc.ca/bulletins/municipal_engineer_article.pdf.

Ferguson, B. (1999). Re-Evaluating Stormwater: The Nine Mile Run Model for Restorative Development. Snowmass, Colorado, Rocky Mountain Institute.

Foy, M. (1997). Restoration in the Lower Mainland. Urban Stream Protection, Restoration and Stewardship in the Pacific Northwest: Are we achieving desired results?, Douglas College, New Westminster, Quadra Planning Consultants Ltd.

Grill, Aaron, (2003) City of Vancouver Engineering, personal communication.

Kulzer, L. R. (1997). Stormwater Quality Control. Urban Stream Protection, Restoration and Stewardship in the Pacific Northwest: Are we achieving desired results?, Douglas College, New Westminster, Quadra Planning Consultants Ltd.

Macdonald, B. (1992). Vancouver: A Visual History. Vancouver, Talonbooks.

Marsh, W. M. (1998). Landscape Planning: Environmental Applications. New York, John Wiley & Sons, Inc.

Paterson, Douglas, (2003) personal communication, UBC.

Pinkham, R. (2000). Daylighting: New Life for Buried Streams. Old Snowmass, Colorado, Rocky Mountain Institute.

Piteau Associates (2000). Restoration of First Creek, Tatlow Park, Vancouver.

Quadra, P. (1997). Urban Stream Protection, Restoration and Stewardship in the Pacific Northwest: Are we achieving desired results?, Douglas College.

SFU (n/d). A Strategic Concept Plan for A Model Sustainable Community in South-East False Creek, Simon Fraser University's Geography 449 class: Environmental Processes and Urban Development.

Vancouver Engineering Water Rates: Cost of Water 2003.