Shelly Creek Water Balance
and
Sediment Reduction Plan

Phase 2 – Computer Modelling and Assessment

Mid Vancouver Island Habitat Enhancement Society

Presented to:

Mid Vancouver Island Habitat Enhancement Society
P.O. Box 935,
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Acknowledgements

The Shelly Creek Water Balance and Sediment Reduction Plan has been completed with the assistance of the following funders:

This report is dedicated to Faye Smith, who was the backbone of stream stewardship in the Oceanside area for the past 30 years. She will be greatly missed.

1. INTRODUCTION

Mr. Jim Dumont has been retained by the Mid Vancouver Island Habitat Enhancement Society (MVIHES) to assist in the assessment of the Shelly Creek watershed. The objectives of the project were:

1) to determine the causes of stream channel erosion in the Shelly Creek watershed, and
2) to determine the water balance for Shelly Creek, and provide a rainwater strategy to restore stream health.

The study is presented in four separate volumes that consist of:

1. **Summary**: is a very brief description of the issues and mitigation strategies;
2. **Technical Summary**; is a document that contains a brief description of the background information and mitigation strategies;
3. **Phase 1**; The detailed collection of information describing the Shelly Creek watershed and the human impacts that have occurred; and
4. **Phase 2**: The detailed description of the stream, the analysis undertaken, and the development of the recommended mitigation strategies.

1.1 Study Area

The Shelly Creek Watershed lies within the Regional District of Nanaimo (RDN) and the City of Parksville as illustrated on **Figure 1-1**. The focus of the Phase 1 was examination of the physical characteristics of the watershed and the processes of change in causing the observed adverse impacts. Phase 2 has focussed upon the stream and has developed a number of strategies to mitigate human induced impacts.

This study has addressed two question that included:

1. What is causing the stream channel to fill with sediment?
2. How can we restore the stream's health?

1.2 Scope of Work

Reported within the previous, Phase 1 document were the results of Phase 1 which include the following specific tasks:

1. Review background information including climate, streamflow, surface soils, surficial geology, surficial hydrogeology, land use planning, OCP, biological information, historical air photos.

   This task has collected available biophysical data and information about the watershed describing the existing conditions plus the historical conditions and provide a comparison that may lead to an indication of the alterations of the watershed that have affected the stream. This will provide insight into the processes and possible mitigation strategies.

   Collection and compilation of biological information has been completed to document the changes in the productivity of the stream and identify deficiencies in aquatic habitat that may be limiting the fishery resource.

2. Undertake a field reconnaissance to determine physical dimensions of the stream at selected locations and of the mineral soil components of the bed and bank of the stream.

   This task provides a specific physical description of the stream channel and its condition relating to stability, the potential for water induced erosion, and hydraulic capacity.

3. Develop a description of the natural Water Balance using recorded climate and stream flow data,

   This task utilized an analysis of the available data and a regional analysis to assist in describing the conditions in the stream. The regional analysis is needed because actual flow records and not available and information is required to proceed to Phase 2.

The Phase 2 report builds upon the results of Phase 1: The tasks completed during Phase 2 include:

4. Prepare and calibrate models for watersheds using the Water Balance Methodology,

   This model building would allow the creation of a watershed model that would replicate the flood discharges and flow durations to provide input into an assessment of available stream habitat.

5. Undertake analysis and develop mitigation strategies for watersheds based upon land use zoning and typical development patterns. The mitigation strategies would fall into two categories:
   a. Physical stream modifications, and
   b. Standards for future development within the watershed.

   This task would assess methodologies and mitigation techniques required to restore the watershed function and stream stability.

6. Provide an overview of the development design and approval processes that identifies the roles and responsibilities of the regulators. Provide comment on the standards and guidelines to provide a description of the processes and how they could be used to implement the mitigation strategies developed as part of this study.

7. A focussed field trip to identify potential stream modification strategies and projects.

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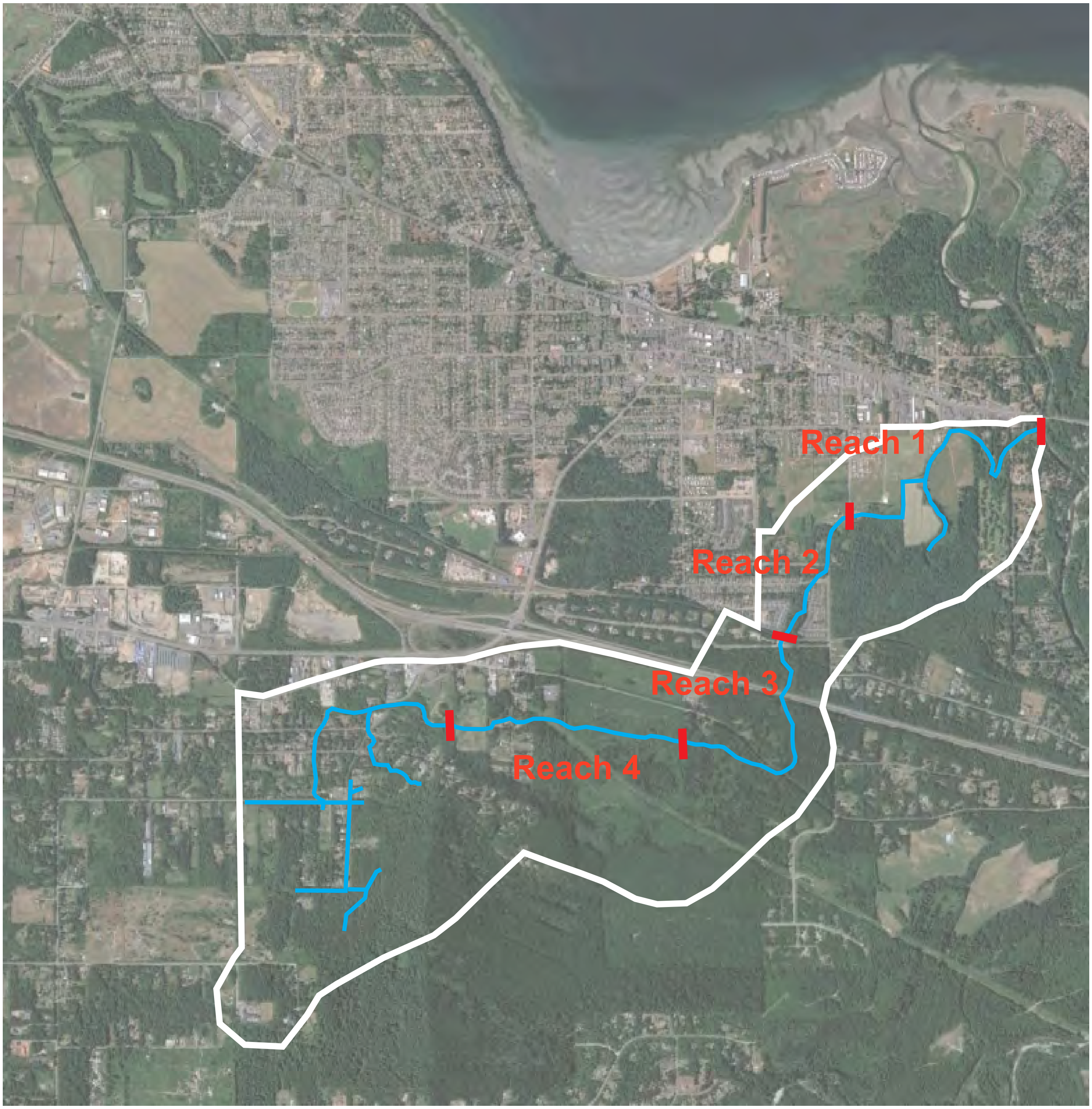

Shelly Creek Watershed
5.21 km^2 521 ha

Stream Reach

Shelly Creek Watershed Plan

Shelly Creek

Figure 1 - 1

1.3 Background Documents and Information

Background information for Phase 2 was derived from a number of diverse sources that included:

1. Shelly Creek Smolt Trap 2011, D. Clough
2. Shelly Creek Smolt Trap 2012, D. Clough
3. Shelly Creek Smolt Trap 2013, D. Clough
4. Shelly Creek Minnow Trapping Results, February 24, 2014,
5. Shelly Creek Coho Smolt Trap Report – 2015, B. Riordan
6. Shelly Creek Stream Assessment and Fish Habitat Survey Report - 2014 and 2015, P. Law, F. Smith, and B. Riordan.
7. Shelly Creek Geomorphic Overview and Conceptual Level Habitat Enhancement Program Development, Northwest Hydraulic Consultants, November 26, 2014.

As additional information becomes available the Watershed Plan can be updated. There should be no immediate need to add a level of detail to the Plan until specific needs are identified by projects that will then obtain the necessary physical data which can then be included in the existing analysis methodology and models. We anticipate little additional cost in data acquisition from future development or municipal infrastructure design and only modest cost to update the watershed analysis as data becomes available.

1.3.1 Smolt and Minnow Trapping

The MVIHES stream stewardship volunteers have been active within the Shelly Creek watershed over the past six years. Estimation of the productivity of Shelly Creek has been examined since 2011 through the use of smolt traps to provide an estimate of fish populations, references 1 through 5 above. The trap is located immediately to the east of the Martindale Road crossing as shown on **Figure 1-2**. The numbers captured in the years of operation are shown in Table 1.1 and indicate a variability that may be dependent upon weather patterns where below average rainfall and above average temperature affect the survivability of the fish as well as their ability to move both downstream and upstream.

Table 1.1 – Numbers of Counted Fish

Year	Salmonid (Coho Salmon)	Trout Rainbow, Cutthroat	Other Sculpin, Stickle Back	Total
2011	2,638	37	206	2,881
2012	8,094	42	337	8,473
2013	7,265	21	388	7,564
2015	1,247	0	480	1,708

The conclusions from the 2011 Smolt Trapping program offered these observations. "*Shelly Creek only has approximately 1000m of anadromous fish access with relatively poor spawning habitat conditions. The large number of smolts found indicates that Shelly Creek offers spawning and rearing habitat within its lower reach. It is also indicated that it is heavily* *used as overwintering habitat during high water by migrating fish from the Englishman River*." This highlights the importance of the lower reaches of Shelly Creek for the production and survival of salmon in not only the creek but also of the much larger Englishman River.

1.3.2 Stream Assessment

In 1999, a stream assessment was completed using the Urban Salmon Habitat Program (USHP) methodology, from the creek's confluence with the Englishman River to the E & N railway. In 2014 a second assessment was completed for the accessible portions of the steam. The stream length was divided into four reaches beginning at the Englishman River as shown on **Figure 1-1**.

Results from the USHP field surveys in 2014 and 2015, provide strong evidence that Shelly Creek is undergoing significant impacts to it's ability to sustain viable biologically functioning aquatic ecosystems. Changes to stream channel conditions over the past 16 years have resulted in severe erosion and deposition of fines, choking off the stream's ability to remain an important contributor to salmon and trout production.

Reach 1

This lower reach of the creek from the confluence with the Englishman River - upstream to Blower Road is 1670m in length and is dominated by the Shelly Farm. Access was not permitted for MVIHES surveyors, however access was permitted for the Geomorphologist review in 2014. As indicated previously Reach 1 as shown on **Figure 1-2** is a very important, as it has anadromous fish rearing in the lower 620m of wetland which crosses Martindale Road. The remaining 60 % of the stream within the reach has been modified for farming. Other significant features include a (manmade) barrier to fish passage and a discharge of stormwater from Stanford Ave.

Reach 2

Reach 2 from Blower Road - upstream to the E&N Railway Crossing is shown on **Figure 1-3**. The reach is 900m in length, and is accessible to resident cutthroat trout. It has a stream gradient of 2% to 3%. The USHP survey was used to continuously assess the channel through the entire reach. The landuse is characterized as small rural properties and urban interface, with three road crossings. The creek's riparian vegetation has been protected in a park above Hamilton Road. In **Table 1.2**, reach # 2 stream data results were compared with the "stream habitat standards" developed by the Ministry of Environment for a typical east-coast Vancouver Island stream. The result is a rating of good/fair/poor for each habitat condition. It can be concluded the reach is in generally "poor condition".

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Photo looking east from Bower Road


Photo looking west from Martindale Road

Smolt Trap circa 2012


Smolt Trap circa 2015

Shelly Creek Watershed Plan

Reach 1

Figure 1 - 2

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Photo looking west from Bower Road


Photo looking north to Hamilton Ave


Photo south of Hamilton Avenue


Photo south of Hamilton Avenue

Reach 2

Figure 1 - 3

Table 1.2 – Reach 2 Habitat Conditions		
Habitat Parameters	**Value**	**Ratings**
% Pool Area	60.69	Good
Mean Stream Depth (m)	0.15	Poor
LWD/Bank Full Channel Width	0.5	Poor
% Cover in Pools	< 5	Poor
Average % Boulder	5	Poor
Average % Fines	45	Poor
Average % Gravel	35	Fair
% of Reach Eroded	34	Poor
Obstructions	27	Poor
% of Reach Altered	10	Poor
% Wetted Area	50	Poor
DO		6.4
Ph		7.5
H20 Temp		15 - 23

Following the USHP methodology a valuable comparison was made using the data collected in 1999 and 2014 for Reach 2. These assessment followed a common methodology that allows for direct comparison of the stream condition at to dates approximately fifteen (15) years apart. The comparison as shown in **Table 1.3** provides an indication of the ongoing changes in the stream that are affecting the channel and aquatic habitat available for fisheries production.

Table 1.3 – Reach 2 Channel Comparison								
Stream Reach	**Blower Rd. - Butler Rd.**		**Butler Rd. - Corfield Glades storm**		**Corfield Glades storm - Hamilton Rd.**		**Hamilton Rd. to E and N Culvert**	
Reach Length	**280 m**		**98 m**		**44 m**		**338 m**	
Survey Year	**1999**	**2014**	**1999**	**2014**	**1999**	**2014**	**1999**	**2014**
% Pool Area	81.1	40.0	100	54.5	100	28.6	61.56	70.13
Debris/ Bankfull Channel Width	0.34	0.47	0.1	0.31	0	0	0.72	0.78
% Cover in Pools	42	44	20	23	5	0	45	37
Average % Boulder Cover	0	0	0	0	3	0	0	4
Average % Fines	20	43.3	5	30	55	0	46.3	72.5
Average % Gravel	80	39.3	75	45	5	0	30	14.3
% of Reach Eroded	0	45.6	29	75	0	0	0	87
# of Obstructions	1	11	0	0	1	1	6	16
% of Reach Altered	0	11.1	64	42	64	92	0	1
% Wetted Area	100	58.8	62.0	49.3	42.8	42.8	32.76	48.3
Stream Temp	14.0	14.9	13.0	15.3	10.8	20	10.4	23
Dissolved Oxygen	6.4	6.2	7.9	7.7	8.7	6.4	8.3	6.4
PH	7.8	7.25	7.8	6.4	7.9	7.7	7.8	7.7

Habitat differences in the reach between the 1999 and 2014 surveys include the following:

- Percent Pool Area – the lower reaches (Blower to Butler Road) of the stream appear to have experienced a decrease (by 50%) in the amount of pool habitat available for fish since 1999. This is a result of sediments from upstream reaches settling into slower pool habitats. Fish are confined to pools in low flow periods, so fewer pools = less habitat available for fish.
- Debris/Bankfull Channel Width – The only significant change in the amount of large woody debris in the area surveyed is between Hamilton Rd and Butler Rd culverts.
- Average Percent Fines: A significant increase in the amount of fine sediment covering the bottom of pools throughout the survey area. Fish do not survive in streams with muddy substrates
- Average Percent Gravels: A decrease in the presence of gravels as a substrate in the stream. Fish require gravels for spawning.
- Percent of Reach Eroded: Significant increases in the erosion of stream banks. The eroded materials are filling downstream pools.
- Number of Obstructions: The survey area had a high number of obstructions to fish movement (upstream or downstream) at

during summer low flows. The dominate obstruction type observed were woody debris (root) jams with gravel plugs. There are 4 road culverts in this reach.

- Percent of Reach Altered: Within the survey area, the Hamilton Road culvert to Butler Road culvert has seen the most “alteration” by humans, in the form of rip rap and wood debris removal.
- Percent Wetted Area: This value is trending negatively, similar to Percent Pool Area (above). The stream’s wetted area is “filling in” due to deposition of sediments from upstream reaches. Erosion of the substrates and stream banks in the reaches above Hamilton Rd is creating more wetted habitats for fish.
- Stream temperatures: The temperature of the upper reaches seemed high in 2014, despite the excellent riparian cover throughout the survey area.

Generally the changes in stream conditions seen in Reach #2 are a result of changes to natural stream flow rates and duration of flow in the watershed caused by changes in land use within the watershed resulting in changes to the hydrology of the Shelly Creek watershed.

Reach 3

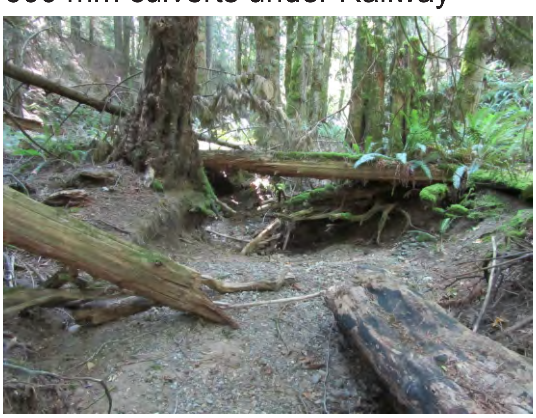
This reach as shown on **Figure 1-4** is located from the E&N Railway Crossing - upstream to Island Timberlands eastern property boundary is 1133m in length with an average stream gradient of 5% to 7%. This reach is confined to a deep forested gully which confines the channel. Several (bankful width) woody debris jams have created obstructions in the channel, where sediment accumulates above the jam and erodes a deep pool into the hardpan clay downstream during high winter flows. The channel is dry from approximately 6 months of the year. Channel assessment took place using a modified USHP format. The USHP survey was used to continuously assess the channel through the entire reach.

Within the reach, there were sixteen (bankful) debris obstructions with accumulated woody debris that accumulate in jams covering thirty two percent of the reach’s length. Three road crossings in this reach (including Hwy. 19) have culverted (altered) twenty two percent of the channel’s length.

The channel conditions appear to be unstable, with forty percent of the reach degrading (eroding) and the remainder being subjected to deposition of sediments during peak winter flows. This reach is devoid of surface water from May to early October every year.

600 mm culverts under Railway

2,500 mm culvert under Wildgreen Way



Erosion in the 'canyon' section

Slope failure of Allsbrook Road

Riparian conditions through much of the reach are excellent, with maturing second growth conifer forest conditions providing stable riparian conditions (Fig. 6). Landuse is primarily forestry (Crown owned). Two hobby farms in the upper portion of the reach have resulted in encroachment of a building and (private) bridge impacting the channel.

Reach 4

Reach 4, or the upper most reach as shown on **Figure 1-5** is located from the east edge of the Island Timberlands Property to the Yates Funeral Home. It is 1300m in length, and is 0.5% gradient. The land use includes the large forestry parcel owned by Island Timberlands, and several hobby farm residential properties.

A striking finding at all locations was the fact that the stream channel is uniform with few natural substrates, showing strong evidence of ditching. Based on the type of land development in this reach (large acreage hobby farms), we conclude the (landowners) desire to ensure adequate drainage of their property has resulted in a channel that has been highly modified by ditching.

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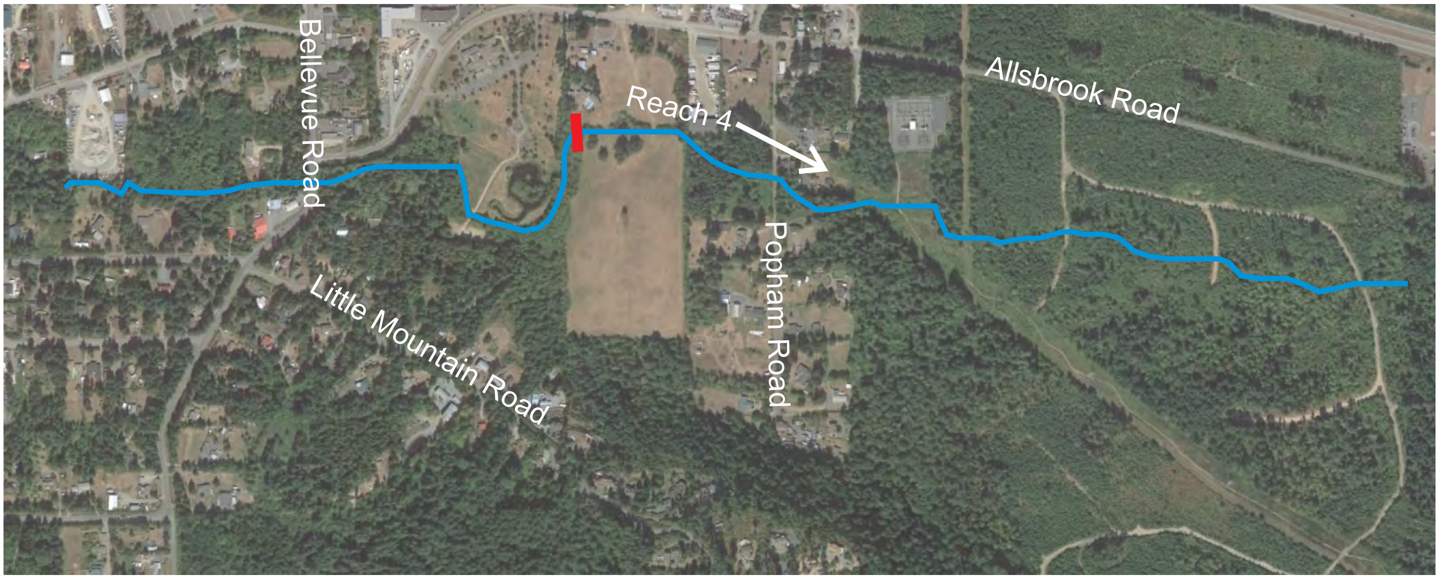


Photo of winter conditions in farm field


Photo of summer conditions in forest lands


Photo looking west from Popham Road


Photo looking west from Bellevue Road

Reach 4

Figure 1 - 5

2. WATER BALANCE

The hydrologic cycle describes the path of water as is circulates through the environment. As rainwater falls from the sky it follows a number of possible paths as shown on the diagram showing the hydrologic cycle on **Figure 2-1**.

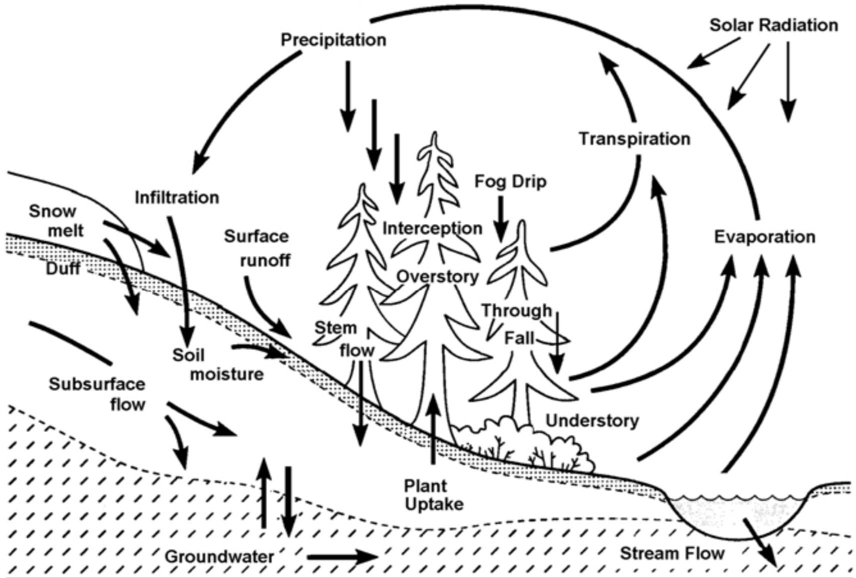


Figure 2-1 Hydrologic Cycle

As can be seen all of the rainwater does not enter the stream. The Water Balance Methodology examines the flow path of water in the watershed, and the flow in the stream.

2.1 Impacts of Development

Development almost universally results in a greater area of imperviousness, less pervious area and a corresponding reduction in vegetation. This will increase the volume of surface runoff and decrease the moisture captured on the surface and which evaporates directly back into the atmosphere.

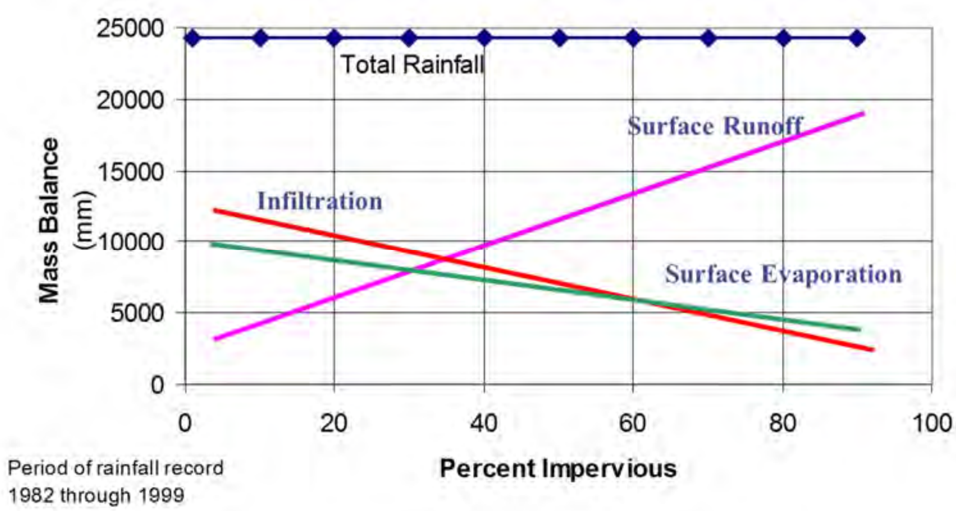
The activities of man which include logging, road and railway construction, agriculture, land development, and building construction will disrupt the natural hydrologic cycle. As land surface condition is altered by man there is less pervious area and a corresponding reduction in vegetation. This will increase the volume of surface runoff and decrease the moisture captured on the surface and which evaporates directly back into the atmosphere. **The purpose of constructed drainage works such as ditching, culverts, and storm sewers is to intercept and direct watershed moisture away from the soil and directly to the receiving stream**.

The multiple risks resulting from development include:

1. **Increased flood risks** in downstream reaches;
2. **Aquatic habitat damage** and the loss of fisheries resources.
3. **Increased erosion** and property damage; and
4. **Costs** associated with flood damage and repairs to eroded streams.

Rainwater management is utilizing natural precipitation as a resource to maintain or to restore the natural water balance within a watershed. This can provide the most effective method of maintaining or restoring the ecological function of the streams and their productivity. **Rainwater management is a concept that applies a state of the art municipal engineering to achieve the desired objective of restoring Shelly Creek**. In a mixed rural and urban area, such as in the Shelly Creek watershed, the goal of mitigating adverse impacts that resulted from existing drainage improvements and development must be a goal applied to the design and approvals of future alterations within the watershed. Note here that future alterations can be subdivision of land, land development, building construction, road construction, ditching, drainage improvements, or other activities that alter the surface of the watershed.

The information on **Figure 2-2** provides a comparison of the water balance across a range of impervious values for a typical west coast watershed over a seventeen year period. This is not a representation of the results of the analysis of the Shelly Creek watershed as some of the values may be different than those observed. Rather this information is used to demonstrate



observed trends across a wide range of locations and conditions.
Figure 2-2 Water Balance Impacts

The information contained in Figure 2-1 can be interpreted to indicate that as the total imperviousness increases from approximately five percent (5%) to ninety-five percent (95%) the following alterations to the water balance will occur:

- Total rainfall remains constant at 24,000 mm;
- Total surface runoff increases from 3,000 mm to 19,000 mm;
- Total surface infiltration decreases from 12,000 mm to 3,000 mm; and
- Total surface evaporation decreases from 10,000 mm to 4,000 mm.

This sample watershed is used only to demonstrate the principles of the impacts of development and the increasing levels of imperviousness. The amount of rainwater returned to the atmosphere can equal the amount infiltrated into the soil. **A mitigation strategy that focuses on surface runoff will ignore the need to increase the amount of soil infiltration that naturally occurs and the actual impacts upon the stream**.

2.2 Rainfall Modelling Approach

As discussed in Volume 1 there are three flow paths of rainwater in a watershed from the point of rainfall until it enters the stream as shown on **Figure 2-3**. The flow paths include:

1. **Surface runoff** where the amount of time water spends on this path is typically in the order of minutes to hours. Where lakes and ponds are a part of the flow path the time could be extended to days.
2. **Interflow** is the shallow unsaturated flow system that varies on a seasonal basis. Water enters the shallow soils and typically flows to a stream within a year.
3. **Deep groundwater** occurs in the saturated aquifer below the water table. Flow in the aquifer can occur over long periods of time extending from years to decades depending upon the length of the flow path and porosity of the aquifer.

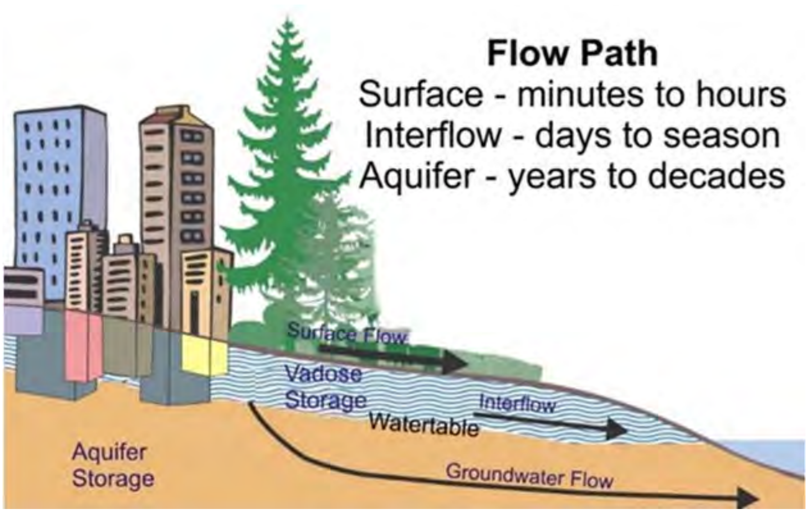


Figure 2-3 Watershed Flow Paths

Addressing stream health forces us to ask how much of the rainfall reaches the stream, through what flow paths, and how quickly. Only by addressing these comprehensive processes can we provide a quantitative analysis of stream health. Therefore the Water Balance Methodology embraces more than the simplistic view of rainfall volume compared to surface runoff volume.

The analysis procedures which when combined are a part of the Water Balance Methodology provide a much greater degree of certainty than the prescriptive approaches which only call for capture of rainwater. Examples of very simplistic prescriptive approaches include:

- Capture ½ Mean Annual Storm, and
- Retain 90% of rainfall on site.

The variability of watersheds includes factors such as aspect, underlying geology, and vegetation which all contribute to variations in the relationship between precipitation and stream flow. While there will be similarities in watersheds situated in close geographic proximity the concept of a universal prescription should not apply.

Rainwater management using a prescriptive approach makes several assumptions, which are seldom stated. Some of these assumptions include:

- All watersheds are similar and that the prescribed capture volume is the same for each watershed and each site;
- Amounts of infiltrated water will be the same and will follow the same flow paths under developed conditions as under undeveloped conditions;
- There is no risk arising from infiltration of the captured rainfall; and
- The rate of infiltration is sufficient for disposal of captured rainwater.

A simple examination of watershed variability leads us to conclude that prescriptive approaches are not desirable and that a better method is required to mitigate the impacts of urban development. Prescriptive approaches do not provide any analytical method of demonstrating effectiveness or their ability to mitigate adverse impacts. Therefore the Water Balance Methodology is superior and should be given preference over any prescriptive approach.

At the center of the **Water Balance Methodology** is the recognition of the different flow paths that rainwater can follow toward a stream and the amount of time it can spend along the way. The Water Balance Methodology recognizes these three flow paths, the length of time required to reach the stream and the necessity or maintaining the natural distribution of rainwater toward these flow paths.

The **Water Balance Methodology** addresses the differences and provides solutions that will maintain the stream health within the developed watershed. The Water Balance Methodology also recognizes the potential change in the paths followed by rainwater in the hydrologic cycle and establishes the methodologies required to protect the stream and the watershed.

An approach to mitigate the impacts of urban development are required for new developments prior to the impacts being incurred and for existing developed areas where the impacts are already occurring. The intent of the **Water Balance Methodology** is to provide a logical and simple way of assessing potential impacts resulting from urban development and to analytically **demonstrate** the effectiveness of the methods proposed for mitigating the potential impacts. The analysis utilizes standard engineering practice while incorporating scientific knowledge from a wide range of sources not normally considered when undertaking drainage design.

The primary impact, as identified above, results from the alteration of the watershed hydrology. The **Water Balance Methodology** provides a framework that allows the alteration to be analyzed and defined. The impacts which have been identified above can then be mitigated and the effectiveness of the mitigation measures can be quantified using an assessment of calculated stream discharges as the primary method to measure success. If the stream flows and durations of flow can be maintained then success can be demonstrated.

The **Water Balance Methodology** has been developed to address the need to mitigate impacts while providing a scientifically defensible approach to assessment, analysis, and design. The **Water Balance Methodology** provides a logical and simple way of assessing potential impacts resulting from urban development and will demonstrate the effectiveness of the methods proposed for mitigating the impacts.

2.3 Impacts and Mitigation

As development proceeds there is a very drastic disruption to the shallow soils as building foundations and underground infrastructure is constructed. These disruptions result in large alteration of the shallow surficial soils and the interflow system with the greatest impacts occurring in the denser developments where the ground disturbances are contiguous.

The post development flow paths for shallow groundwater are disrupted and this invalidates the assumption that prescriptive approaches are applicable in all locations.

Development almost universally results in drainage improvements, a greater area of imperviousness, less pervious area and a corresponding reduction in vegetation. **The purpose of constructed drainage works such as ditching, culverts, and storm sewers is to intercept and direct watershed moisture away from the soil and directly to the receiving stream**. Using the existing standards of practice for drainage, as regulated by the BC Ministry of Transportation and Infrastructure, elevated stormwater discharges from developments have resulted in negative impacts to Shelly Creek. **Continuing to use the accepted standard of practice as applied to design of human activities which include municipal engineering and land development will result in further environmental degradation of the watershed and loss of stream productivity.**

The multiple risks resulting from development include:

1. **Increased flood risks** in downstream reaches;
2. **Aquatic habitat damage** and the loss of fisheries resources.
3. **Increased erosion** and property damage; and
4. **Costs** associated with flood damage and repairs to eroded streams.

The alterations to the landscape will increase the volume of surface runoff and reduce the volumes lost to the air through evaporation and transpiration. If the runoff volume is to be maintained then a larger volume must be infiltrated into the ground. Where the terrain is steep constraints soil stability may be adversely affected which would result in an increased risk to people and property. In areas located on clays, bedrock, or high groundwater levels infiltration rates may not be sufficient to allow large rates of infiltration. In these locations the only acceptable method of managing the extra volumes is to discharge to the stream through the drainage system but at rates that are sufficiently small and will not increase stream erosion. The flow duration assessment which is part of the Water Balance Methodology is used to demonstrate that stream erosion can be controlled to predevelopment rates, or reduced if this is a desirable outcome of mitigating the impacts of development.

Mitigation of adverse impacts can be divided into separate approaches based upon the surface type as either pervious or impervious.

2.3.1 Pervious Surfaces

The alteration of the hydrologic response of a watershed can affect even the pervious surfaces. For example the vegetation and trees can be cleared to provide grassy surfaces and the top soil can be removed and not replaced. If the pervious surfaces are protected and no harmful alteration occurs then they will respond in a hydrologically similar manner following development. This implies that the soil and its rainwater holding capacity are preserved through careful topsoil and vegetation management. Where pervious surfaces are disrupted then the prime objective would be to restore the infiltration capacity and to replace or augment the top soil so as to mitigate impacts to the hydrologic responses of those disturbed areas. If preservation of pervious area conditions is assured then the focus of the assessment can be on the effect of the impervious areas.

2.3.2 Impervious Surfaces

The conversion of areas from pervious to impervious will prevent rainwater infiltration and results in almost all of the rainwater being converted into surface runoff. There are some evaporation losses that can become significant. The mitigation of this hydrologic change is the challenge and municipal infrastructure must be designed to replace the lost natural retention systems and flow paths. The infrastructure used to mitigate the impacts would receive the surface runoff from the impervious areas and then operate in a manner which would replicate the interflow system while limiting the infiltration to deep groundwater to naturally occurring rates. The mitigation of the adverse impacts is aimed at areas which will have reduced top soil depths and areas where there will be in increase in the imperviousness. Where the impervious surface area occurs then mitigation will be required in the form of retained and detained rainwater in direct proportion to the imperviousness. That is the greater the imperviousness then the greater the mitigation required. The watershed target for impervious surfaces is to replace the lost area that connects the surface to the saturated aquifers.

2.3.3 Mitigation System Criteria

Construction of drainage infrastructure and site development causes a disruption to interflow through the shallow surface soils. The storage capacity of the shallow surface soils is considerably reduced resulting in the loss of the storage reservoir of the watershed. The interflow system is replaced by drainage systems which convey water very rapidly and contain far less storage capacity than the surface soils. The loss of the interflow system is a very significant impact to the natural environment that results from urban development. Mitigation of this impact is essential in a developed urban setting. The shallow soil storage and the interflow conveyance system must be replicated in order to mimic the natural watershed.

The deep groundwater flow path cannot be the only one that remains following development because of the time scale over which it occurs is significantly greater that the response of the lost interflow system. This implies that an amount of infiltration to deep groundwater must be maintained and not significantly increased or decreased.
A system that mimics the natural watershed must include:

1. The interflow system which must allow stored water to enter the stream from the shallow systems, rather than relying entirely upon groundwater discharge.
2. The overflow rates must be controlled to prevent increased risks for flooding of properties downstream of any specific development.
3. The flow to aquifers has been assessed using a sensitivity analysis combined with the storage size and controlled discharge rates. This avoids the potential of either reducing the aquifer, or of increasing the flows to the aquifer and any transference of flooding through release of groundwater.

These factors combine to create a system that can be optimized to maintain both the volumes and the rates of discharge to the stream.
The objective of Rainwater Management is to provide the interflow connectivity to the stream and to maintain or decrease potential flood risks, and to mimic the amount of water that was infiltrated to groundwater under natural watershed conditions. This approach provides a level of assurance that:

1. Excess water will not be directed to the ground and would avoid potentially adverse impacts of excessive groundwater levels and discharges in areas lower in the watershed.
2. Summer flows will be maintained with an operating interflow system when combined with aquifer discharge.
3. Downstream properties will not suffer an increased risk of flooding or flood damages.

2.3.4 Mitigation System Analysis

The hydrologic aspects of the development can be described through the use of a suitable continuous simulation model. The simulation of the watershed and the areas undergoing redevelopment can be modeled with a standard modeling approach using continuous climate data as previously described. The simulation of the watershed, plus retention and discharge control systems can be added to the computer model by defining the processes as shown on **Figure 2-4**.

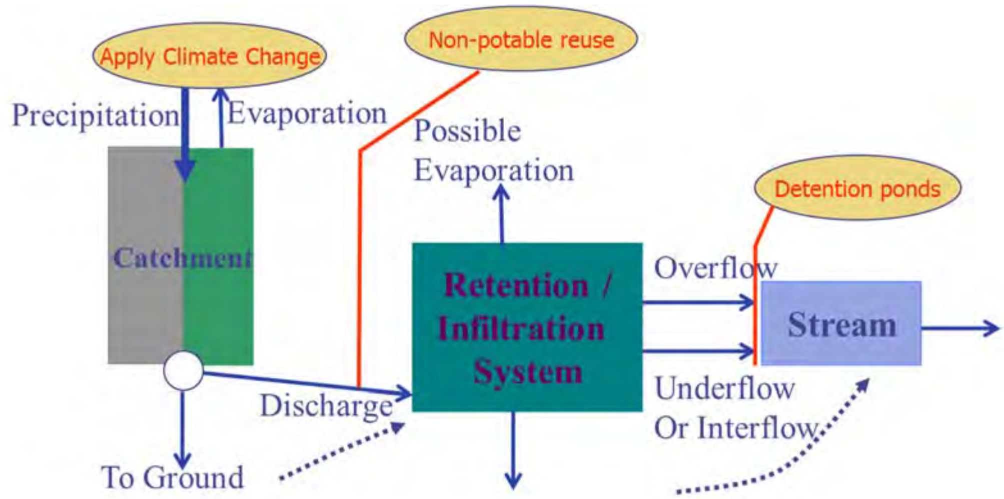


Figure 2-4 Watershed and Rainwater Control System Operation

The objective of Rainwater Management is to mimic the amount of water that was infiltrated to groundwater under natural watershed conditions, provide the interflow connectivity to the stream and to maintain or decrease potential flood risks. This approach provides a level of assurance that:

- Excess water will not be directed to the ground and would avoid potentially adverse impacts of excessive groundwater levels and discharges in areas lower in the watershed.
- Summer flows will be maintained with an operating interflow system.
- Downstream properties will not suffer an increased risk of flooding or flood damages.

The criteria used to measure success would be:

- No increase in magnitude of flood events,
- No increase in the duration of Q_2 and Q_5 discharge rates to prevent increased stream erosion, and
- No increase in the losses to deep groundwater.

Examination of the process flow chart in **Figure 2-4** leads to the conclusion that there are three physical characteristics of the retention / infiltration systems that can be varied to influence the hydrologic operation of the rainwater control systems. The three physical characteristics include:

1. **Volume of retention** which stores rainwater for controlled release to deep groundwater / aquifer or to the stream through the municipal drainage system;
2. **Infiltration system area** in contact with the subsurface which will allow retained water volumes to infiltrate to deep groundwater / aquifer; and
3. The **base flow release rate** which can be used to augment small stream discharges through release of retained rainwater.

The analysis which is a part of the Water Balance Methodology will seek to minimize the volume of retention and the infiltration system area while maintaining the selected base flow release. A sensitivity analysis will search for the minimum retention / infiltration system size while achieving the stated objectives. <u>This allows for a focus upon the least cost system to mitigate the impacts of urban development.</u>

2.3.5 Rainwater Management Targets

The results of the rainwater analysis will yield three targets required to achieve the objectives, these being:

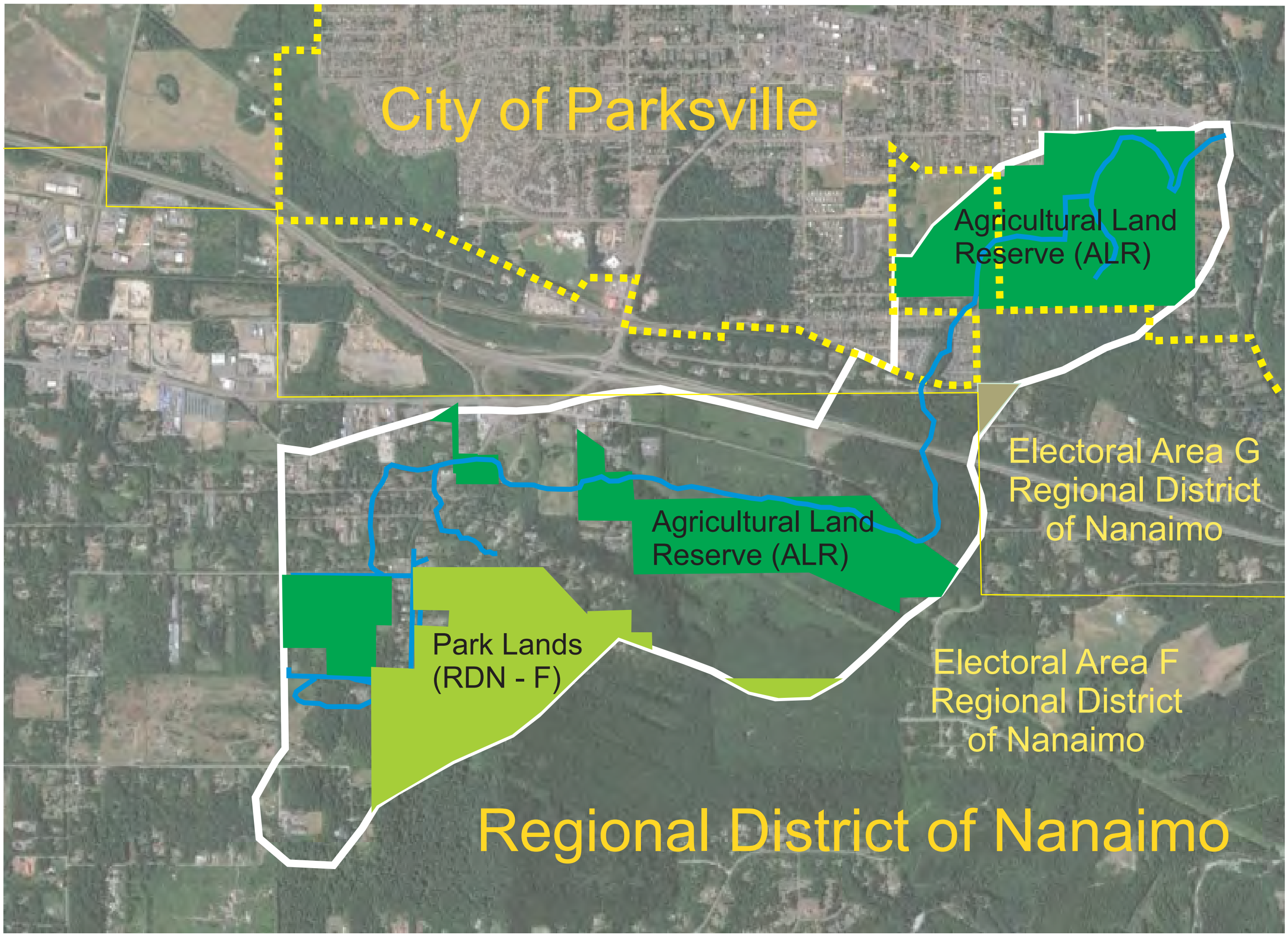
1. **Retention Volume** expressed in of m^3/ha of development,
2. **Base Flow Release Rate** from retention expressed in of L/s/ha, and
3. **Infiltration Area** for the retention facilities expressed in m^2/ha of development area.

2.4 Land Use in the Shelly Creek Watershed

Development within the Shelly Creek watershed is comprised of man-made alterations to the natural environment. The current and proposed mitigation strategy will provide additional capability of economic growth while planning is undertaken to minimize the associated adverse impacts to the natural environment. The potential development is restricted by the Official Community Plans created by the City of Parksville and the Regional District of Nanaimo for the two electoral districts as shown on **Figure 2-5**. The areas that are highlighted have two significant development constraints which include:

1. The Agricultural Land Reserve which is governed by the British Columbia Land Reserve Council. While the lands are subject to clearing and farming the potential for residential development can be considered to be minimal at this time. Although farming would generally retain the pervious surfaces there would be pressure by the property owners to enhance the drainage and to further alter the hydrology of the areas. This has been previously discussed in **Section 1.3.2.4**.
2. The land use zone identified as Park within Electoral Area F would be subject to the any decisions of the RDN to modify the zoning or the land types and configuration of land surfaces within the area.

All other land within the Shelly Creek watershed is subject to development following the existing land use designations, or to other land uses with a revision to relevant OCP.



Shelly Creek Watershed
5.75 km^2 575 ha

Non-Developable Lands
Figure 2 - 5

2.5 Shelly Creek Watershed Water Balance

As discussed previously the flow path of water through a watershed is as important as how the water enters and leaves the watershed.
One over simplification that is often made involves comparing surface runoff and precipitation. However when considering stream health it is critical to expand this view to include flow in the stream and the two flow paths through the soil for water to enter the stream.

The standard of practice of engineering and the specific applications in drainage design places a special emphasis upon on creating infrastructure with the sole purpose of reducing surface flooding and inconvenience for infrequent large storm events such as a 1 in 5 or 1 in 25 year return period. Many currently available urban runoff models have their roots in drainage design where the emphasis is with very large and rare rainfall events. In contrast, rainwater management and stream health problems are associated with common and relatively small rain events with a return period of less than a 1 in 6 month event. This leads to the conclusion that the commonly used computer models are not applicable to assessing impacts to the aquatic environment or to determining the appropriate mitigation systems.
The assumptions and simplifications that are legitimately used with drainage design models are not appropriate for models used in assessing stream impacts and rainwater management systems.

The continuous hydrologic simulation allow us to demonstrate our understanding of the existing watershed hydrology and stream discharges. The model is then used to demonstrate that the application of mitigation measures can allow urban development without altering the hydrology and would thus prevent damages to the aquatic environment. The second benefit derived from this analysis methodology would be to demonstrate that urban development can occur without the typical increase the risks and damages associated with flooding along the streams of the watershed.

2.5.1 Computer Model and Continuous Simulation

The seasonal movement of rainwater through the interflow system on its way to a stream suggests that the computer models that would be used to describe the processes must be capable of extended duration of analysis. This also suggests that the existing engineering standard of practice of using a single design storm will not adequately provide sufficient information to allow a description of the impacts of development on the watershed. Nor would the standard of practice allow the creation of a mitigation strategy to eliminate adverse impacts resulting from development.

The selection of continuous simulation uses many years of recorded climate data and stream discharge for establishing the framework for the study and to establish watershed targets for implementation.

The assessment of the Shelly Creek watershed was undertaken with the QUALHYMO computer model using continuous simulation with recorded climate data that included hourly precipitation, hourly temperature and monthly evaporation from the Nanaimo Airport.

The calibration period has been limited to the twenty-one (21) year period from 1985 through 2005 which represents the period of overlap where both stream flow records for Bings Creek and climate records for Nanaimo Airport are available. As noted in Volume 1 the Nanaimo Airport climate station will be used in conjunction with the Bings Creek stream gauging station.

QUALHYMO incorporates hydrologic process descriptions to more accurately predict the range of stream flows from a range of storm sizes which are of most interest in rainwater management and analyses. The processes that are included within the computer model include evaporation, surface infiltration, soil moisture content, interflow and flow into deep groundwater. QUALHYMO can be effectively used in conjunction with drainage design models to incorporate the mutual benefits of rainwater controls on drainage design.

A primary benefit of continuous simulation is that the frequency of various conditions and system operations can be estimated more easily than when alternate approaches are used. The hydrologic response of watersheds depend not only on the rainfall volume and temporal distribution, but also on antecedent conditions such as soil moisture and the volumes of existing water retained from previous storms. All of these factors overlie the physical characteristics of a watershed in terms of vegetative cover, imperviousness, connectivity, slope, and the many defining parameters describing the condition of the soils.

Continuous simulation allows a direct observation of the frequency of the condition of interest from the modelling results, and therefore accounts for the effect of joint probabilities of intensity, volume, duration, antecedent rainfall and other hydrologic factors which would affect discharge rates and volumes.

Any system that utilizes storage and by default a restricted discharge capacity is extremely sensitive to conditions prior to any actual rainfall event. A period of relatively low intensity of rainfall, but with a considerable volume of rainfall, may fill, or at least partially fill, any system storage available. The system will then react quite differently to a significant rainfall event than had the system storage been empty. This meteorological series of events is common in the Shelly Creek watershed. Hence the source controls are subject to conditions that are not normally given consideration in other geographic locals.

It is important to note that the continuous simulation accounts for the effect of sequential rainfall events and extended durations of rainfall. If an on-site system utilized retention and is designed with a low effective outflow rate, it is possible that a sequence of small storms will successively raise the water level by increasing the system storage. This would leave the system effectively unable to contain and control relatively minor rainfall intensities.

The continuous hydrologic simulation allow us to demonstrate our understanding off the existing watershed hydrology and stream discharges. The model is then used to demonstrate that the application of mitigation measures can allow urban development without altering the hydrology and would thus prevent damages to the aquatic environment. The second benefit derived from this analysis methodology would be to demonstrate that development can occur without the typical increase the risks and damages associated with flooding along the streams of the watershed.

2.6 Model Verification

Verification of the computer model is essential to the process of accurately developing the watershed target values for the Shelly Creek watershed. The calculated flows from the model require a record of stream flow for comparison purposes during the model verification process.

Calibration of the computer model generally would involve matching the calculated watershed discharges with the recorded discharge values when applying the recorded climate data for the watershed. As the climate station is not located within the watershed there is the potential there may be differences in the specific events recorded at the climate gauge when compared to the recording gauge measuring stream discharge. While the climate records from the Nanaimo Airport climate recording station would be representative of the climate experienced within the Bings Creek watershed there will occur instances when recorded discharge events do not correspond perfectly with the recorded climate events. This would occur if a localized storm were to be recorded at the climate gauge while no storm were to occur in the watershed. Alternatively a storm in the watershed may not occur at the climate gauge. There may not be a one for one correlation between recorded precipitation events and the recorded stream flow events. However the number and magnitude of the recorded events should be representative of annual and long term hydrology.

Due to the potential differences in precisely matching each event a more pragmatic process has been undertaken to demonstrate that the continuous simulation model is providing an accurate representation of the hydrologic response to the climate data. The process of verification of the hydrologic model would be to demonstrate that the predicted flood frequency is achieved along with the volumes of discharge measured by the stream gauge.

At this juncture it must be noted that at a watershed scale the micro differences in soils, vegetation and geography will not be identifiable. Rather the watershed approach assumes an averaging of these across the watershed. Without much more extensive climate data, stream flow records and detailed soils investigations some watershed averaging is required. This is both a good thing and one which has some drawbacks. The good is that the targets and standards are developed and can be uniformly applied within the watershed. The less than good is that some variations in local site conditions may not be recognized. However this will not have an impact upon the watershed as the variability will be offset by a variation in the opposite direction on a different site within the watershed. Therefore using watershed average values will result in impact mitigation which will be appropriate given the entire watershed and the study area.

2.6.1 Flood Discharge Verification

As the climate records are not within the Shelly Creek watershed a verification process was undertaken. This process involves matching the flood peaks as represented by a flood frequency analysis and the discharge volume as measured an annual basis. Discussed here is the flood frequency verification.

Shown in **Table 2.1** are the flood frequency based upon a unit area discharge for Shelly Creek and the calculated values as produced by the QUALHYMO computer model for a natural area. The estimation of flood discharges by the model for Shelly Creek are very close to the recorded values for Bings Creek and replicates the discharges estimated from recorded stream flow.

Table 2.1 – Flood Frequency Comparison		
Return Period (years)	Shelly Creek Discharge (L/s/ha)	Bings Creek Discharge (L/s/ha)
200	17.8	17.1
100	16.4	16.3
50	15.0	15.4
25	13.6	14.3
10	11.7	12.4
5	10.2	10.7
3	9.0	9.0
2	7.9	7.4

A graphical presentation of this comparison is shown on **Figure 2-6**.

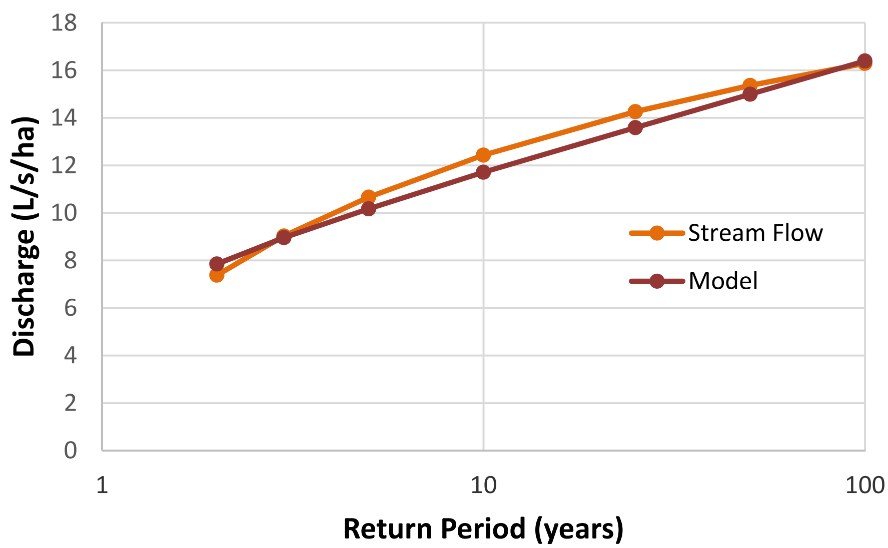


Figure 2-6 Model Verification Comparison

This very close correlation is a demonstration that the computer model has been verified and that it will provide an accurate representation of the stream flow and watershed discharge.

2.6.2 Model Parameters

The computer model parameters derived in the verification process are listed below.

Impervious surface parameters

- initial abstraction or depression storage 2.5 mm
- evaporation from surface allowed
- predevelopment conditions 0.005% impervious

Pervious surface parameters

- initial abstraction or depression storage 20.0 mm
- soil moisture minimum 150 mm water equivalent
- soil moisture maximum 250 mm water equivalent
- initial soil moisture 150 mm, represents initial value
- evaporation from surface allowed

Snowmelt parameters

- snowmelt begins at 0^{o} C
- snow coefficient 0.125
- Initial snow pack depth 0 mm
- Ground flux coefficient 2.5
- Ratio of soil conductivity over depth 15
- Coefficient of daily heat flux 1.1
- Snow pack thermal insulation factor 150
- removal from watershed not allowed

There is uncertainty with the ultimate development conditions as the development process will likely result in revision of the OCP and the current designated Land Use Zoning. This results in an uncertainty as to the factors that affect the hydrologic response of the watershed. These factors include:

1. Nature of Pervious cover is affected by the type and age of the vegetation. Mature undisturbed forests have a much different response that a farm field that has had ditching to facilitate rapid drainage.
2. The amount of impervious surface associated with the land use zoning is not established. Therefore the actual amount of impervious area within the watershed is difficult to estimate for the ultimate development condition. The increase in imperviousness will increase both the volume and the rate of discharges within the watershed.

2.6.3 Importance of Subsurface Discharges

To demonstrate the importance of interflow and groundwater to the water balance and to the flood events the interflow and groundwater routines in the model were turned off and estimates of flood discharges directly resulting from surface runoff were assessed. The resulting flood frequency of the surface runoff when compared to the total discharge are shown in **Table 2.2.**

Table 2.2 – Flood Frequency of Surface Runoff			
Return Period (years)	Modelled Total Discharge (L/s/ha)	Surface Runoff Discharge (L/s/ha)	Surface Runoff as a Percent of the Total Flood Discharge
200	17.8	17.1	37
100	16.4	16.3	36
50	15.0	15.4	35
25	13.6	14.3	34
10	11.7	12.4	32
5	10.2	10.7	31
3	9.0	9.0	30
2	7.9	7.4	28

The comparison of total flood discharge rates and those resulting from only surface runoff are shown on **Figure 2-7**.

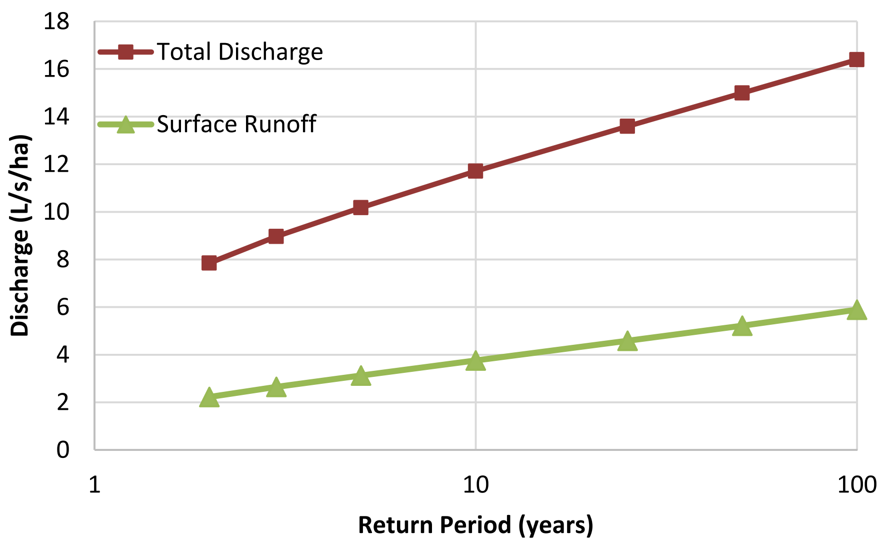


Figure 2-7 Surface Runoff versus Total Flood Discharge

There are significant contributions of discharge from the interflow and groundwater flow paths. The information presented in Figure 2-7 indicates that under natural conditions only about 30 to 40 percent of the total discharge rate is from surface runoff. The smaller and more frequent events have the smallest surface runoff component. Put another way; the majority of discharge is from the interflow and groundwater flow path and only during the very largest of floods does surface runoff become important. This is further emphasized in **Section 2.6.4** below.

2.6.4 Water Balance of Shelly Creek Watershed

The Water Balance of the Shelly Creek watershed was reported in Volume 1 and is of sufficient importance to repeat here. The identified flow paths and relative volumes associated with each flow path are shown in **Table 2.3**.

Table 2.3 – Annual Water Balance of Shelly Creek Watershed

Flow Path	Total (mm)	Total (%)
Precipitation	**1,170**	**100**
Evaporation and Transpiration	**235**	**20**
Stream Flow	**935**	**80**
Surface Runoff	115	10
Aquifer Recharge / Discharge	120	10
Interflow	700	60

The interflow system has been identified as a critical flow path within the watershed yet it is not well understood by many land development engineers. I must assume that this is a case of out of sight and out of mind. Another assumption that is often made by land development engineers is that any water that infiltrates into the ground will eventually end up in the stream. However if we consider the information presented in Volume 1 concerning soil physics of water flowing through soil and the evidence of the pedology (soil formation process) then it is obvious that the interflow system is very fragile and subject to unintended damage.

The interflow system is very shallow, typically less than 1 m from the ground surface. Flow within the interflow system can readily be intercepted by simply building a road and ditch to improve the drainage of a land parcel. Any ditch will allow the interflow to be intercepted and will thus allow the water to be collected and diverted to the stream much quicker than would naturally occur, within a few days rather than over the course of a season. While this does not increase the peak discharge to the stream it does reduce the discharge in Shelly Creek within a few days of dry weather and far sooner in a dry period such as occurs each summer.

2.6.5 Mitigation Analysis

The analysis has been undertaken in a manner so as to answer the question “how can the developments within the Shelly Creek watershed mimic a natural watershed?”

The natural watershed will have the flood frequency and total volumes of stream discharge. The objective of the analysis is to identify the components and systems required to be constructed in the Shelly Creek watershed within new developments and within redeveloping areas to mimic the natural watershed hydrologic conditions.

The objective of this part of the assessment is to describe a system of drainage infrastructure that can be used to mitigate hydrologic impacts and allow the developed watershed to mimic the natural

Water Balance. As discussed in **Section 2** the objective of Rainwater Management is to mimic the amount of water that was infiltrated to groundwater under natural watershed conditions, provide the interflow connectivity to the stream and to maintain or decrease potential flood risks.

The water balance approach provides a level of assurance that:

- Excess water will not be directed to the ground and would avoid potentially adverse impacts of excessive groundwater levels and discharges in areas lower in the watershed.
- Low summer flows will be maintained with an operating interflow system.
- Downstream properties will not suffer an increased risk of flooding or flood damages.

The criteria used to measure success would be:

1. No increase in the duration of discharge to prevent increased stream erosion,
2. No increase in magnitude of flood events, and
3. No increase in the losses to deep groundwater.

The analysis presented in this report focuses upon maintaining the flood frequency and the water balance of the Shelly Creek watershed. Given the travel time of rainwater to the stream the very short duration of time within a pipe system is not a critical or important factor in the assessment. Rather the processes that are occurring over the period of days and seasons are more critical and hence a model that focusses upon those longer term processes is more appropriate.

The Water Balance Methodology as applied in this study has examined the stream discharges to determine what is happening and to identify the methods required to keep them healthy.

As described in **Section 2.11** of **Volume 1** the infiltration rate from the rainwater retention systems is assumed to be 2.5 cm per hour at a depth of approximately 1.5 m. The flow to ground has been assessed using a sensitivity analysis which combines the retention volume, infiltration area and the base flow release rate to minimize the retention / infiltration system size. This allows identification of the least cost system to mitigate the impacts of development.

The **Base Flow Release Rate** has been set at the mean annual stream discharge value to allow any stored volume to augment the low summer flows in the stream. This rate of 1 L/s/ha provides a direct connection and an assurance that the volumes will be controlled and released in a manner that mimics the interflow in the natural watershed.

The overflow rates have been controlled to provide a post development flood frequency equivalent to the natural watershed. The 2 year return period flow rate of 7.9 L/s/ha has been established as the maximum rate for release from storage without an overflow. Controlling discharges to these rates will eliminate the risk of increased flooding in downstream reaches of the Shelly Creek watershed.

The remaining two target values were established using an iterative process. They included:

- The **Retention Volumes** is required to limit the flood frequency of discharges, to allow time for infiltration to ground, and to provide a volume to augment low stream discharges.
- The surface contact area of the infiltration systems, **Infiltration Area**, is required to achieve the desired volumes of infiltration to deep groundwater so as to mimic predevelopment conditions and achieve the water balance of discharges to the stream, surface evaporation and losses to deep groundwater. This area should not be overly large to prevent excess discharge to deep groundwater. Alternatively this area should not be so small that it would reduce the volumes discharging to deep groundwater.
- Amounts of additional **detention** required on a neighbourhood basis to reset the downstream flood risks to those of predevelopment conditions.

A statistical analysis of both the annual maximum discharges and the annual maximum retention volumes yielded the values associated with a range of return periods and probabilities of occurrence.
A number of alternative retention / infiltration system sizes were assessed to establish the minimum size that would achieve the performance criteria. The minimum size is provides the meets the stated criteria and objectives with a minimum of installed infrastructure. Hence this would provide a system that will meet the goals and objectives at a minimum cost.

2.6.6 Shelly Creek Watershed Targets

The target values specific to development areas with disturbed areas and higher impervious values which include residential, commercial, industrial, institutional and higher density residential and most road Rights-of-Way include the following:

1. **Retention Volume** 150 m^3/ha of impervious area,
   - For example a house, patio, or road with an area of 100 m^2 would require a volume of 1.5 m^3.
2. **Infiltration Area** 5 m^2 per 100 m^2/ha of impervious area.
3. **Base Flow Release Rate** 1.0 L/s/ha, and
4. **Neighbourhood Detention** 100 m^3 / ha of development with a controlled maximum release rate of 7.9 L/s/ha with an allowance for overflows.

The optimized storage and infiltration system required to achieve the first objective of maintaining the durations of discharge within Shelly Creek can be demonstrated in the discharge exceedance relationship as shown on **Figure 2-8** for the 21 year period from 1985 through 2005.

The information shown describes the results for four development scenarios which include:

1. Natural conditions,
2. Exiting conditions,
3. Possible future conditions if no mitigation works are utilized, and
4. Future conditions with mitigation measures applied.

A description of the information contained within the chart and of its importance follows the image. The information contained in the chart is explained in the text following the chart.

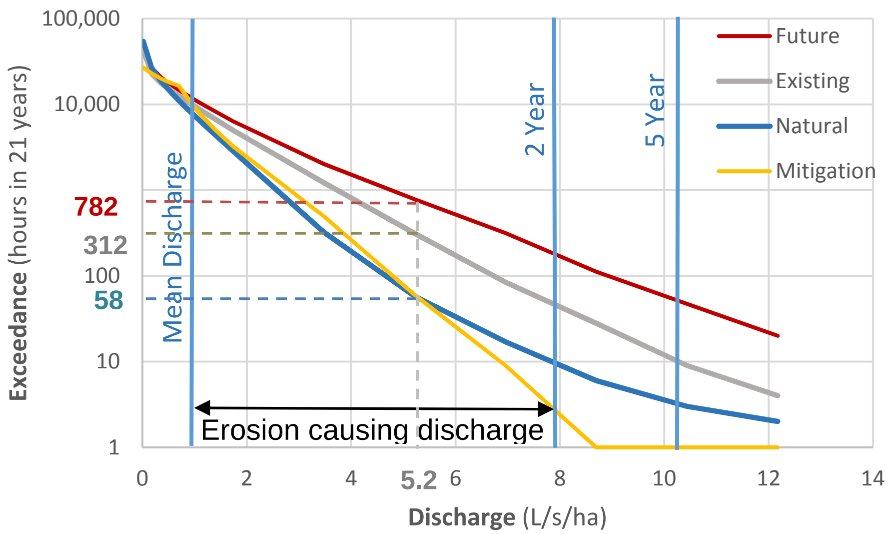


Figure 2-8 Discharge Exceedance

The information describes the flow exceedance values for the four watershed conditions. It can be interpreted for the predevelopment conditions in the following manner:

- The mean discharge for natural watershed condition of the Shelly Creek watershed is approximately 1 L/s/ha and was exceeded for 6,900 hours during the 21 year period. This means the flow was greater than 1 L/s/ha during 6,900 hours and less than 1 L/s/ha for the remaining time during the 184,000 hours in the 21 year period. It would be reasonable to assume that this is a safe discharge which would not result in stream erosion.
- The 2 year return period natural flood discharge of 7.9 L/s/ha was exceeded for just 10 hours during the 21 year period. This leads us to conclude that the discharges that cause the observed stream erosion must be less than the 2 year return period discharge rate. While this discharge rate will cause erosion it very seldom occurs.
- For example the **hours of exceedance** for a discharge rate of **5.2 L/s/ha have increased** over the 21 year period, from the **predevelopment conditions** of **58 hours**. The **existing conditions** to the **312 hours,** and **for future conditions** can

be increased to **782 hours.** This indicates a possible **14 fold** increase in the duration of erosion causing discharge rates.

- **We can conclude that the vast majority of stream erosion is caused by discharge rates between the mean discharge and the 2 year return period flood event**. The majority of the stream erosion is caused by watershed flow rates from 1 to 8 L/s/ha. For the 575 ha Shelly Creek watershed this would be equal to discharges into the Englishman River over a range from 575 L/s (0.575 m^3/s) to 4,600 L/s (4.6 m^3/s).

Even under existing conditions the hours of erosion causing discharges have increased by a factor of more than 5 times over the natural conditions. This increase in the flow duration is the cause of the increased steam erosion observed in Shelly Creek.

Implementing the recommended mitigation measures can restore the duration of the erosion causing discharges to their natural values and would restore the hydrology of the stream.
The detailed numbers for each development scenario are presented in **Table 2.4** for the 21 year period from 1985 through 2005.

Table 2.4 – Flow Exceedance Values

Discharge (L/s/ha)	Natural (hours)	Existing (hours)	Future (hours)	With Mitigation (hours)
0.17	26746	22669	26782	22998
0.35	18898	17834	20991	20108
0.52	14444	14788	17319	17989
0.70	11112	12513	14730	16459
1.04	6939	9127	10903	8449
1.39	4418	6729	8296	5084
1.74	2846	4961	6356	3236
3.48	322	1216	2015	493
5.22	58	312	782	60
6.96	17	84	315	9
8.70	6	28	112	1
10.43	3	9	47	1
12.17	2	4	20	1

The second criteria of restoring the flood risk potential to Shelly Creek. This is defined as not increasing the magnitude of the historic floods. For example the 5 year return period flood under natural conditions is 10.2 L/s/ha or 5.31 m^3/s discharging into the Englishman River. Any increase in this rate will result in larger floods and potentially more property damage. Any future drainage system whether or not it includes mitigation must not increase the size of the floods and the potential for property damage or risk to people within the watershed.

The potential to increase or decrease the flood risk can be demonstrated through the flood frequency values associated with the four watershed conditions as discussed in above. The flood frequencies associated with the four watershed conditions can be seen on **Figure 2-9**. A description of the information contained in the chart and its importance follows the image.

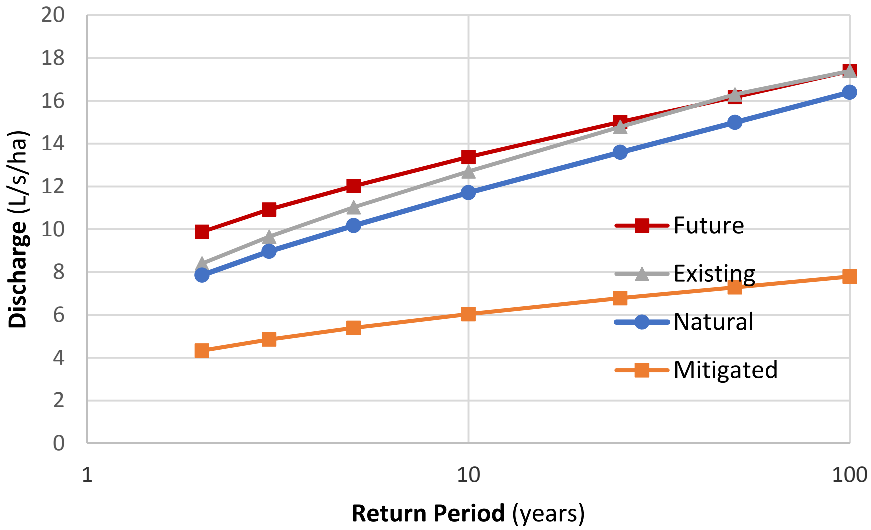


Figure 2-9 Flood Discharge Estimate

As can be seen the flood frequencies for the fully mitigated watershed condition can be reduced through achieving the watershed targets for future watershed conditions. The key information contained in the chart is that the size of the smaller floods will increase as development increases unless there is an effort to mitigate the impacts of development. The 5 year flood has increased from 10.2 L/s/ha (5.8 m^3/s) for the natural watershed to the existing condition of 11.0 L/s/ha (6.3 m^3/s) and to a possible 12.0 L/s/ha (6.9 m^3/s). The increase in size and magnitude of these flood events will result in more property damage and greater risk to personal safety.

A second observation can be made is that the size of the very infrequent flood events will not increase as a result of more development within the watershed. We attribute that to the existing drainage systems combined with ditching and culverts that have already been constructed within the watershed. This means that significant changes have already been made and that have altered the watershed and damage has already occurred to Shelly Creek.

A third observation that can be made is that with future mitigation works the size or magnitude of the flood discharges can be greatly reduced. The benefit to the watershed would be reduced flooding during and reduced risks to people and property along Shelly Creek.

The detailed numbers associated with the flood frequency analysis are shown in **Table 2.5**.

Table 2.5 – Flood Frequency Analysis				
Return Period (years)	**Natural Discharge** (L/s/ha)	**Existing Discharge** (L/s/ha)	**Future Discharge** (L/s/ha)	**Mitigated Discharge** (L/s/ha)
200	17.8	19.3	18.5	8.3
100	16.4	17.4	17.4	7.8
50	15.0	16.3	16.2	7.3
25	13.6	14.8	15.0	6.8
10	11.7	12.7	13.4	6.0
5	10.2	11.0	12.0	5.4
3	9.0	9.7	10.9	4.9
2	7.9	8.4	9.9	4.3

The values provided in **Table 2.5** support the information presented on **Figure 2-9** that demonstrate that changes to the watershed will increase flood risks unless mitigation measures are implemented.

3. MITIGATION STRATEGIES

Mitigation strategies for the restoration of Shelly Creek must be implemented in the watershed and not be restricted to the riparian corridor along the stream. **Without restoration of the hydrology of the watershed any enhancements or stabilization of the stream may not be successful in restoring the productivity of Shelly Creek.** Therefore it is critical that all mitigation activities target the restoration of the hydrology of the Shelly Creek watershed.

The stream has been affected by alterations in the watershed hydrology which has caused by human intervention in the watershed. The alterations have included:

- Logging and reduction of the forest cover that increase watershed discharges,
- Construction of roads and ditches which intercept interflow and facilitate more rapid drainage of precipitation falling on the watershed,
- Redirection of flow paths to increase the contributing area of the watershed, and
- Construction of hard surfaces that contribute larger discharge volumes at a higher rate than naturally occurred.

The mitigation strategy and any constructed works must comply with the originally stated requirements for the Shelly Creek watershed that would reduce the stream erosion. Achieving this objective can be accomplished by reducing the duration of erosion causing stream discharges. Restoration of the watershed interflow system can be accomplished over time as opportunities arise through the development and redevelopment processes of the RDN and the City of Parksville.

The mitigation strategy has a series of opportunities can be applied and a system to prioritize these can be used to rank each specific opportunity. The suggested prioritization of the opportunities can be based upon:

1. Must provide a part in reducing stream erosion and restoring the fish habitat along Shelly Creek;
2. Must meet the objective of maintaining and restoring the interflow system and watershed hydrology; and
3. Cost of implementation, higher cost options are less desirable.

At this time six opportunities have been can be placed into two broad categories that include:

A. **Implementing Rainwater Management** with opportunities 1 and 2.
B. Implementing **stream channel projects** at specific locations with opportunities 3, 4, 5, and 6.

These opportunities and are shown on **Figure 3-1** and include:

1. Throughout Shelly Creek Watershed - enforce MOTI guidelines for subdivisions and work with Parksville to adopt similar standards;
2. Throughout the Shelly Creek Watershed - Utilize Water Balance Express for all future building permit applications;
3. Infill excavated ditch;
4. Creation of off-channel habitat;
5. Maintain and construct new structures as opportunity allows; and
6. Construct works to stabilize channel erosion.

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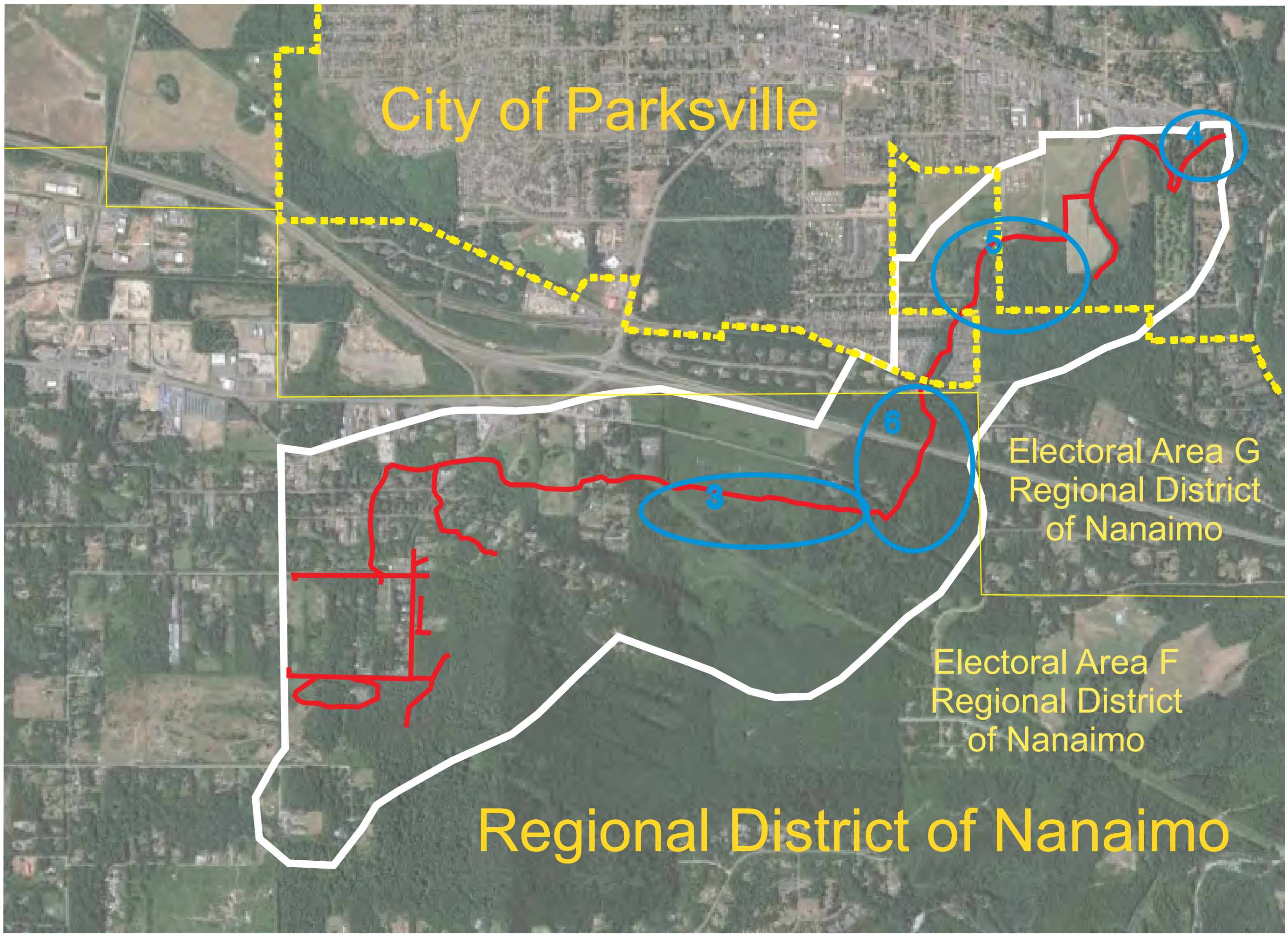


1 Enhancement Opportunities

1. Throughout Shelly Creek Watershed - enforce MOTI guidelines for subdivisions and work with Parksville to adopt similar standards
2. Throughout the Shelly Creek Watershed - Utilize Water Balance Express for all future building permit applications.
3. Infill excavated ditch
4. Off-Channel Habitat
5. Maintenance and new structures upon opportunity
6. Log Weirs to Stabilize Channel Erosion

Shelly Creek Watershed Plan

Enhancement Opportunities

Figure 3 - 1

3.1 Enforce MOTI Design Guidelines

A majority of future subdivision will occur within the RDN where MOTI is the review and approving agency for subdivision and drainage design. The design criteria used for MOTI and subdivision projects were updated and included in the B.C. Ministry of Transportation Supplement to TAC Geometric Design Guide (2007) within Chapter 1010 General Design Guidelines, 1010.03 Requirements for Drainage Designs, subsection Land Development Drainage Design. MOTI should adopt the requirements of this drainage plan for application of the water balance methodology within the Shelly Creek watershed to future subdivisions.

In the instance of drainage design there are six guiding statements within the chapter that include the following:

- *"an increase in downstream flooding or stream erosion will not be allowed. Designs will achieve this requirement unless it can be demonstrated that these changes do not adversely impact property or the environment"*
- *"All drainage systems must include run-off controls to limit post-development peak discharge rates to the pre-development rates for 5 year return period storms."*
- *"Un-attenuated flood waters in excess of the 5 year discharge that by-pass the detention facility must not adversely affect the receiving ditch or channel. Documentation of this assessment is required for all projects."*
- *"The Subdivision Development Drainage Report must provide sufficient information to allow the reviewer to understand the developer's objectives and to thoroughly assess the hydraulic impacts of the development."*
- *"An additional Ministry requirement is an assessment of the receiving ditch or watercourse for peak flows greater than a 5 year return period up to a 100 year return period. The assessment must document the net change in water velocity in the ditch or receiving water, identify any potential impacts from increased peak flows, and make recommendations for mitigation. In other words, flows must be managed to ensure that no increase in flooding and stream erosion occur as a result of development storm drainage."*
- *"In areas where a Master Drainage Plan has been developed, all subsequent drainage designs should conform to the plan."*

The intent of MOTI is clear in providing these statements that there should be no increase in flooding or stream erosion resulting from subdivision. The final statement indicates that where a Master Drainage Plan exists the subdivision designs should conform to the plan. In the case of the Shelly Creek watershed this study can be considered the drainage plan that identifies the requirements for developments to achieve a net benefit in restoring the hydrology of the watershed and stream through the use of the water balance methodology. MOTI should adopt the requirements of this drainage plan for application of the water balance methodology within the Shelly Creek watershed to future subdivisions.

The City of Parksville is required through provincial legislation to establish the drainage criteria that would apply within the City. The City should adopt the requirements of this drainage plan for application of the water balance methodology within the Shelly Creek watershed to future subdivisions.

3.2 Implement the Water Balance Express

The Water Balance Express for Homeowners has been created by the Partnership for Water Sustainability for British Columbia to provide guidance in restoring site conditions to their natural hydrologic function. The objective is to provide a simple tool that will allow a home owner to return the hydrology of their property to a natural condition. This process used the watershed targets as described in **Section 2.6.6**. It is intended that the Express be utilized during the on-site construction activities that are regulated through the building permit processes within both the City of Parksville and the Regional District of Nanaimo. These activities would not involve a subdivision and would not be subject to review by MOTI, hence the need for a separate mitigation strategy.

The target values specific to development areas with disturbed areas and higher impervious values which include residential, commercial, industrial, institutional and higher density residential and most road Rights-of-Way include the following:

1. **Retention Volume** 150 m^3/ha of impervious area,
    - For example a building, patio, or road with an area of 100 m^2 would require a volume of 1.5 m^3.
2. **Infiltration Area** 5 m^2 per 100 m^2/ha of impervious area.
3. **Base Flow Release Rate** 1.0 L/s/ha, and
4. **Neighbourhood Detention** 100 m^3/ha of development with a maximum controlled release rate of 7.9 L/s/ha and an allowance for overtopping.

In the simplest of terms the rainwater management system on-site might be envisioned as a simple rain garden as shown on **Figure 3-2**.

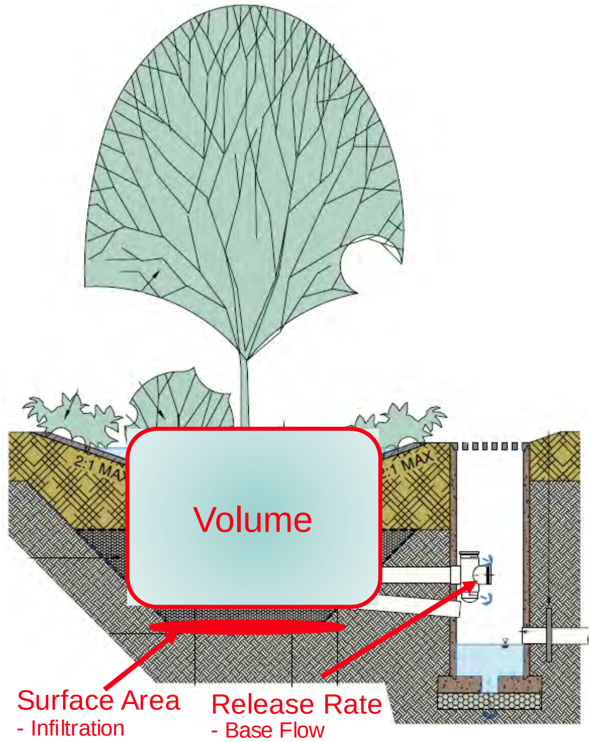


Figure 3-2 Typical Rain Garden

Many other methods of achieving the watershed targets are available and will be described in the following section.

Other Regional Districts have versions of the Water Balance Express and can be viewed to see how simple the model is and how decisions can be made. One example as implemented in the Comox Regional District can be tested at this web site: http://comox.waterbalance-express.ca/

Implementing the Water Balance Express will require changes to the administrative processes for building permitting in both the RDN and the City of Parksville. Both organizations will require bylaw amendments, or new bylaws to allow the implementation and ongoing maintenance of rainwater management systems on private property. We anticipate the construction and certification would occur as part of the building permit and construction process.

3.2.1 Implementation of Rainwater Management

I note that there are three potential impacts that result from development within the Shelly Creek watershed and that these include:

1. Increases of flood discharge and the risk of flood damage;
2. Increased channel erosion resulting from a range of discharges associated with larger of volumes of stream discharge, or put another way an alteration of the Water Balance of the watershed.
3. Alteration of, and damage to, the aquatic environment and its value as a result of alteration of the Water Balance of the Watershed.
   I assume that the mitigation measures will be included in any redevelopment of existing built up areas in addition to any new developments. Therefore implementing the retention and discharge facilities as described would allow the Water Balance and flood risks within the Shelly Creek watershed to be returned to levels that would be representative of natural

conditions for flood risk and stream flow duration by using the mitigation opportunities as they arise.

The rainwater management systems envisioned would provide a developed watershed provide with a hydrologic response and flood risks which would be equal to those found if no development were to have occurred. This study did not examine the flood capacity and risks of the stream channel and cannot confirm whether there is capacity within stream channel to safely convey additional flood discharges without increasing the flood risks associated with the peak discharges from developed areas within the Shelly Creek watershed.

3.2.2 Types of Management Systems

Two basic types of physical mitigation measures can be defined by their operational characteristics. The two types include landscape features and retention systems. :

1. **Landscape surface features** that capture and contain rainwater before it has an opportunity to begin to flow over the surface. These systems can be described as rainwater absorption devices because they act to prevent surface runoff. These features can include enhanced topsoil and other absorbent features built with the intent to retain rainwater without having surface runoff.
2. **Volume retention systems** capture and store surface runoff while allowing the volume to infiltrate deeper into the ground. Where surface runoff occurs then the systems are no longer acting to absorb rainfall, rather they are containing and managing surface runoff. This is how the two types are differentiated. The retention systems would typically be connected to, and receive runoff from, an impervious surface such as a building roof or a driving surface. These retention systems must be constructed with a base flow release system to allow a portion of the drained water to flow into the drainage system so as to mimic the lost interflow system.

3.2.3 Siting the Rainwater Absorptions Systems

As described in **Volume 1, Section 2.10** the key to rainwater absorption landscaping features is to have a soil texture with approximately equal proportions of sand, silt and clay. This soil texture will retain a maximum amount of soil moisture for plant use. A soil with a greater proportion of sand will only temporarily detain rainwater as a sand soil will drain and dry out quickly.

The ideal soil will be a Silty Loam or a Clay Loam with no more than 8% organic content by weight. Excess organic matter will reduce the load carrying capacity of a wet soil and create a boggy condition when the soil is wet.

Any areas that are disturbed by a development process should be restored with no less than 150 mm and up to 300 mm of topsoil as described above.

3.2.4 Siting the Volume Retention Systems

Volume retention systems have three physical components which include and accommodate the watershed target criteria for:

- A detained volume,
- A control to allow baseflow release, and
- A surface contact area to allow infiltration to deep groundwater.

Plants within additional landscaping features may be desirable in retention systems so that retained water can be utilized for transpiration. Consideration for landscape irrigation can also be considered during the design of the retention systems however caution should be used as the volumes required may be significant and may result in the need for a water diversion licence from the Province.

The potential shape and appearance of the volume retention systems is limited only by our imagination and constraints of a site and regulatory concerns. Several retention systems are shown in **Figures 3-3 through 3-7.**

Figure 3-3 Street Raingarden

Figure 3-3 shows a conventional street raingarden with landscaping and surface treatment that can be located within an urban setting. These conventional systems include a list of plants which are selected for this application and generally to minimize future maintenance. Some municipalities will include maintenance as part of their responsibility and cost while others view these facilities as a benefit to the property and expect the adjacent property owner to be responsible for maintenance costs for the vegetation to the edge of the roadway pavement structure.

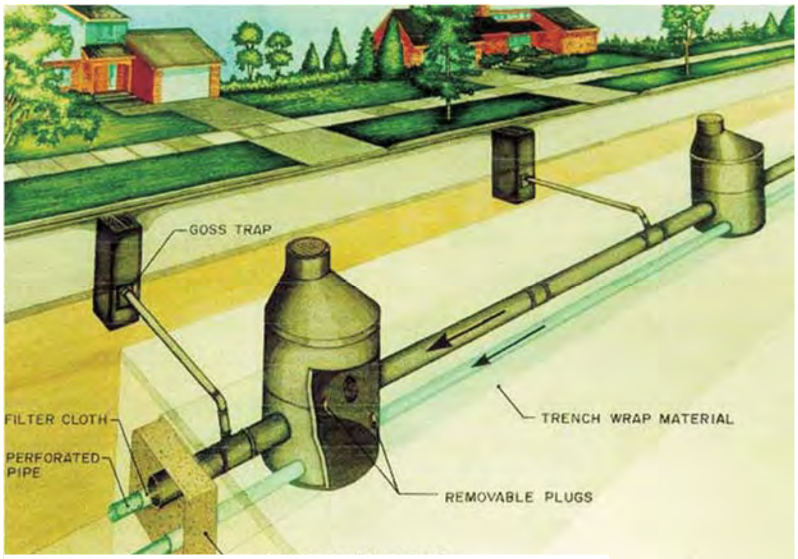


Figure 3-4 Under Street Raingarden

Shown on **Figure 3-4** is an urban approach which would provide the storage, release, and infiltration area in a location that would not disrupt the surface, no increase in the maintenance costs of landscaping. The systems are located completely underground and within the municipal street Rights-of-Way. In this instance the removable plugs would eliminate discharges into the system during construction and would be replaced with flow restrictions to control the rate of base flow discharge from detained storage.

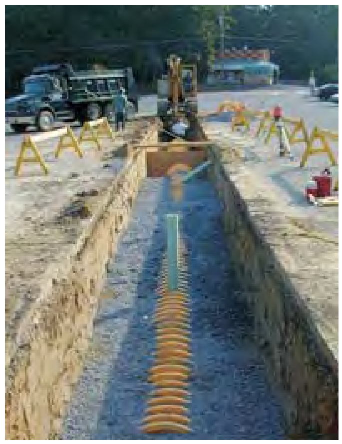
Figure 3-5 Under Lot Raingarden

An underground system that can be located on private property in an urban is shown on **Figure 3-5**. The installation and final finished product are shown. While this is a larger unit suitable for a large property, smaller versions can be constructed for single family lots. A feature of many of the products available for this type of installation is a surface H-20 load rating which would allow trucks to cross the systems without causing damage. These could then be located beneath parking lots or other landscape features without affecting the use and occupation of the surface landscape outside of the building footprint.

A retrofit solution for an existing parking lot is shown on **Figure 3-6** where the material is shown being installed along with the finished product. These are relatively inexpensive facilities for a retrofit situation and could dramatically reduce the disruption and cost of surface restoration over other system configurations.
The key to successfully incorporating the detention systems into the shelly Creek watershed would be to provide for each of the three target values for each site and installation at the time of development or redevelopment. The three targets include:

1. Detention volume to reduce the downstream risk of flooding and to achieve a natural water balance for developments
2. Provision of a baseflow release from detention storage to augment stream flows.
3. A limit on the surface area of raingarden and infiltration facilities that would divert the captured rainwater volume to deep groundwater.

Material for Installation



During Construction

After Construction

Figure 3-6 Under Parking Lot Raingarden

As can be seen in the Figures and system descriptions there are a great many methods of achieving the targets.
In rural areas there are fewer constraints available to use the ground surface and many more alternatives are available as shown on **Figure 3-7**. Generally these are small areas where the ground surface has been depressed below the surrounding surface and which will receive runoff from impervious areas. These can have natural vegetation or can be small wetland areas. The key components will include these features:

- Depressed ground surface to contain and to pond water temporarily.
- A top soil or planting media that will retain water for plant growth,

A water storage area beneath the top soil that will detain water for infiltration into the ground and that will be connected to the drainage system to allow small controlled release.

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Roadside Raingarden

Roadside Raingarden

On-lot Raingarden

Disconnected Downspout

On-lot Raingarden

On-lot Raingarden

Different Rain Gardens

Figure 3 -7

3.2.5 Trade-off Considerations

As the redevelopment occurs within the Shelly Creek watershed new developments occur and as older housing is replaced there exist opportunities to bring about changes in our use and construction standards that can have a benefit to the natural health of the streams.

I believe that the future watershed can become a very exciting and environmentally valuable habitat and a jewel which would be an example that other municipalities would aspire to equal. This change in the watershed would occur over time as redevelopment occurs and as houses are reconstructed without the need for municipal resources on private property. As roadways are reconstructed similar facilities should be constructed to manage and enhance the hydrologic response of municipal land.

3.3 Infill Excavated Ditch

The channel through Reach 4 exhibits visual evidence of having been excavated, or enlarged. While this channel flows through a wooded area without risk of direct flood damages the need for enhance drainage can be questioned. Should the property owner agree it would be a simple matter to infill parts, or all of, the channel to restore this area's condition to that of a floodable forest. This opportunity is shown on **Figure 3-8**.

Restoration of the natural land surface by infilling the ditch, or by partially blocking the ditch will recreate the floodable forest that is the natural condition of this area. The floodable forest is not a readily identifiable wetland with standing water, however it served an important role in slowing the discharge of water into Shelly Creek.

The floodable portion of the forest was not wet sufficiently to affect the soil formation processes as described by the soils reports in **Section 2.8 of Volume 1**. The soils formed with well to moderately drained soils that were not subject to high or to a perched water table.

The vegetation of this area was affected by the quantity of shallow interflow and this is visually obvious on **Figures 3-8** where it can be seem that the trees are not as closely spaced and are a mixture of deciduous and coniferous species. Whereas the vegetation of adjacent areas are closely spaced and comprised primarily of coniferous forest species.

An option for the land owner might be to create a small wetland with a permanent water body to aid in retaining and detaining runoff from those portions of the watershed to the south and west.

Other channels such as roadside ditches can be infilled provided there is sufficient retained capacity for a 1:2 year storm and that water does not overtop the roadway or encroach onto the driving lanes.

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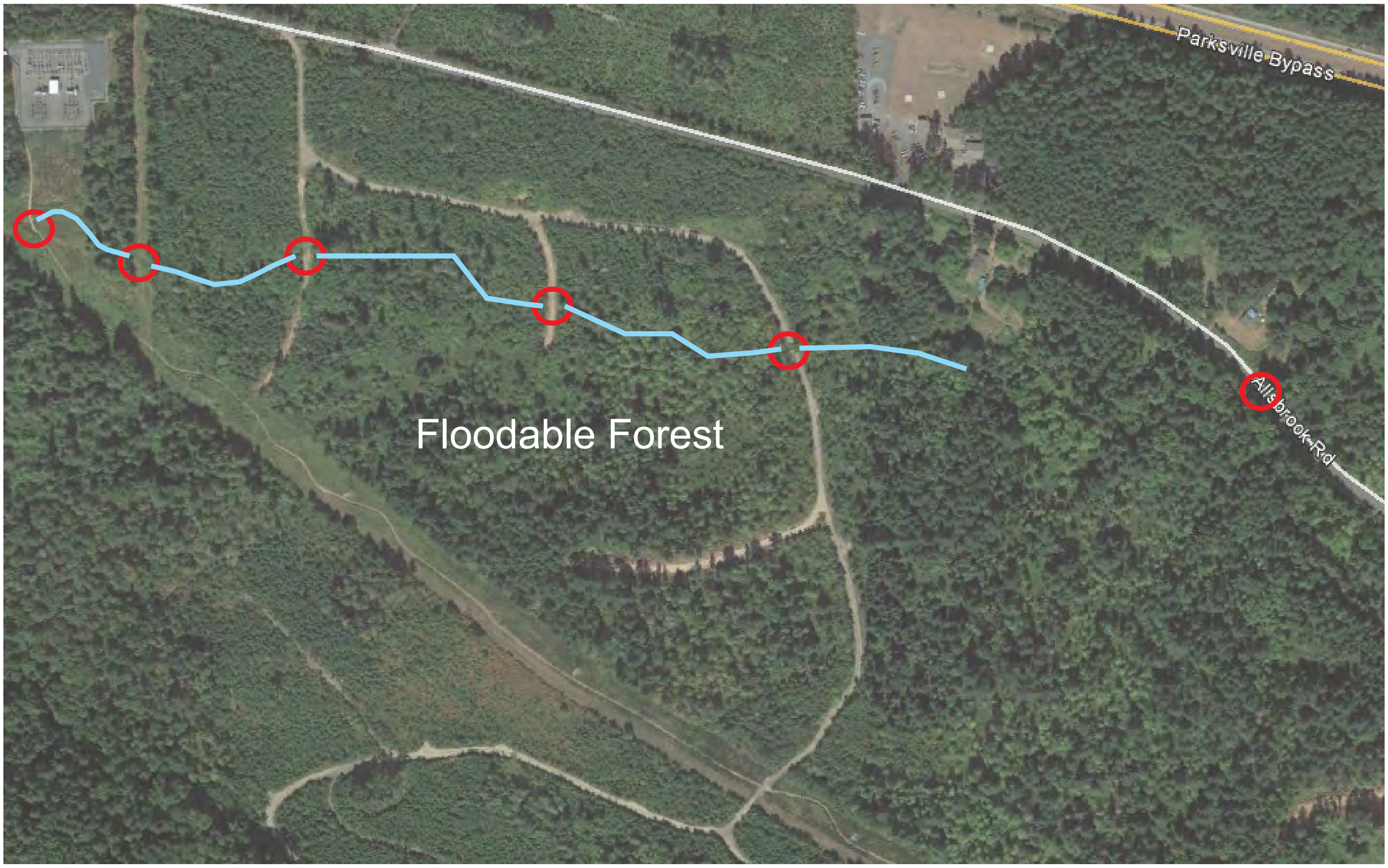

Culvert Location

Ditch Elimination

Ditch Elimination

Figure 3 - 8

3.4 Off-Channel Habitat

The importance of Reach 1 in providing rearing habitat has be reported during the smolt trapping program. The shallow slope of the channel within Reach 1 provides a location for sediment deposition of the material that has been eroded from Reach 2 and Reach 3.

The primary purpose of the off-channel habitat would be to provide aquatic habitat that is not subject to sediment carrying discharges. The off-channel habitat should connect to the main stem at the downstream extent of each habitat section to reduce the sediment load and maintenance requirement for the habitat.

It is hoped that ultimately the stream erosion in Reached 2 and 3 can be reduced and sediment loading to Reach 4 would become normalized. This would, over time, reduce the need to provide the habitat that is being lost due to sediment deposition within Reach 1. The location of the opportunities are shown on **Figure 3-9**.

The off-channel habitat would be constructed through clearing a sufficient number of trees to allow access by an excavator. The channels would then be excavated with the excess material being left mounded nearby to provide a suitable location for maintenance access or for revegetation and restoration of the disturbed site. The depth and width of the constructed habitat would be established as part of a design to add the most beneficial habitat characteristics. Only the most downstream end of the off-channel habitat would be connected to the main stream to prevent the sediment from entering and depositing in the new habitat.

3.5 Maintenance and New Structures

The discussion of Reach 2 provided a view of a stream reach that is undergoing a change induced by the altered hydrology of the upper portions of the watershed. The stream channel is getting wider and the typical flow depths are getting smaller over time. This is an important reach as it marks the upper limit of permanent discharge with water from a number of seeps and springs providing flows during the dry summer season. Resident trout have been observed in the portion of the channel immediately below the upper spring.

Until the upper watershed hydrologic functions are mitigated and returned to normal there is a need to enhance and stabilize Reach 2 with the addition of grade control structures. These structures can be envisioned as Newberry Weirs similar in form and function to those that have been installed in the area shown on **Figure 3-10**. Stabilizing this reach will reduce the sediment load reaching Reach 1. As part of the design process, other structure configurations can be considered.

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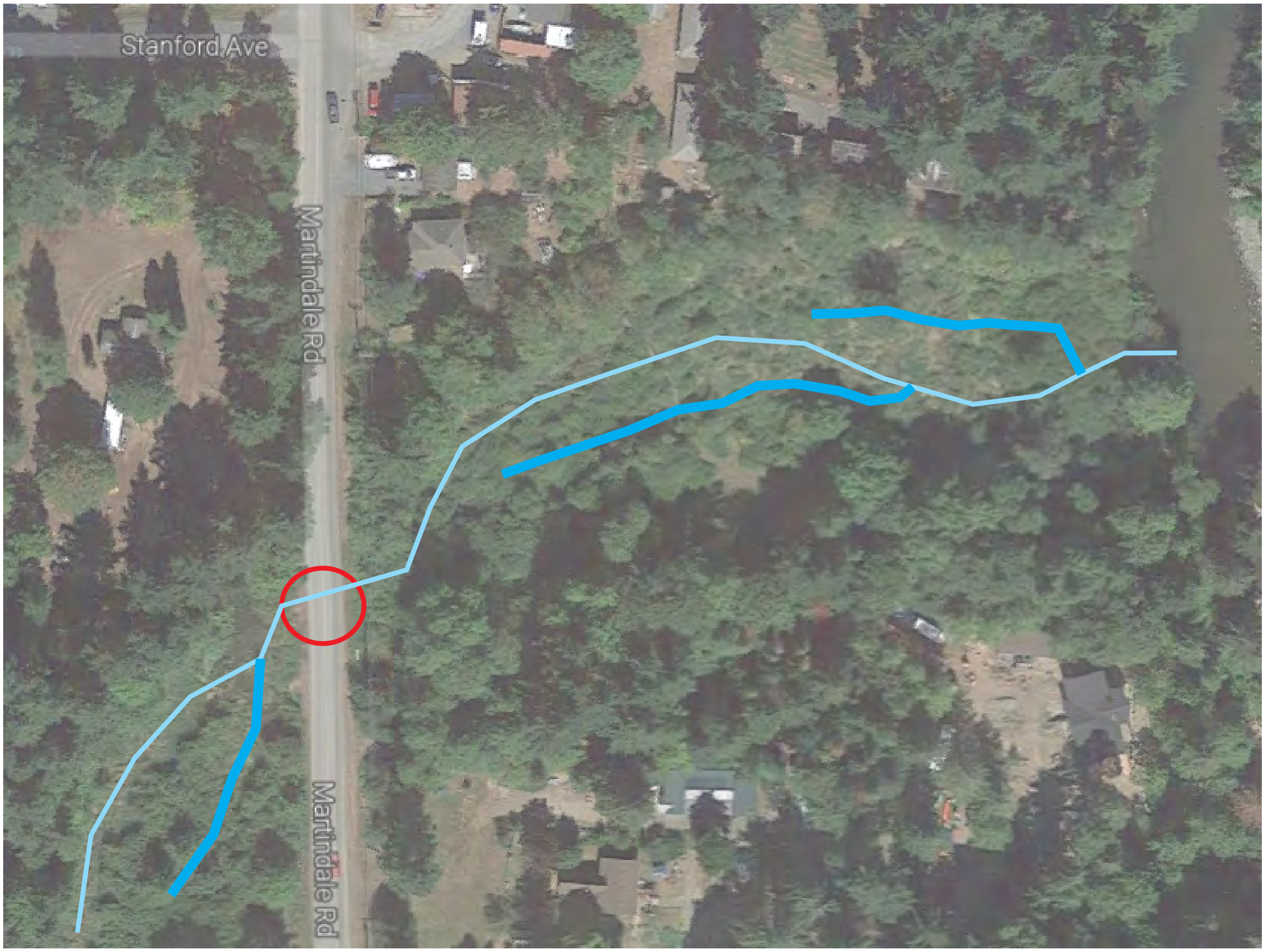

Culvert Location

Off Channel Habitat
- connected to main channel at down stream end

Off Channel Habitat
Figure 3 - 9

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Culvert Location

Existing Structure

Shelly Creek Watershed Plan

Maintenance and New Structures

Figure 3 - 10

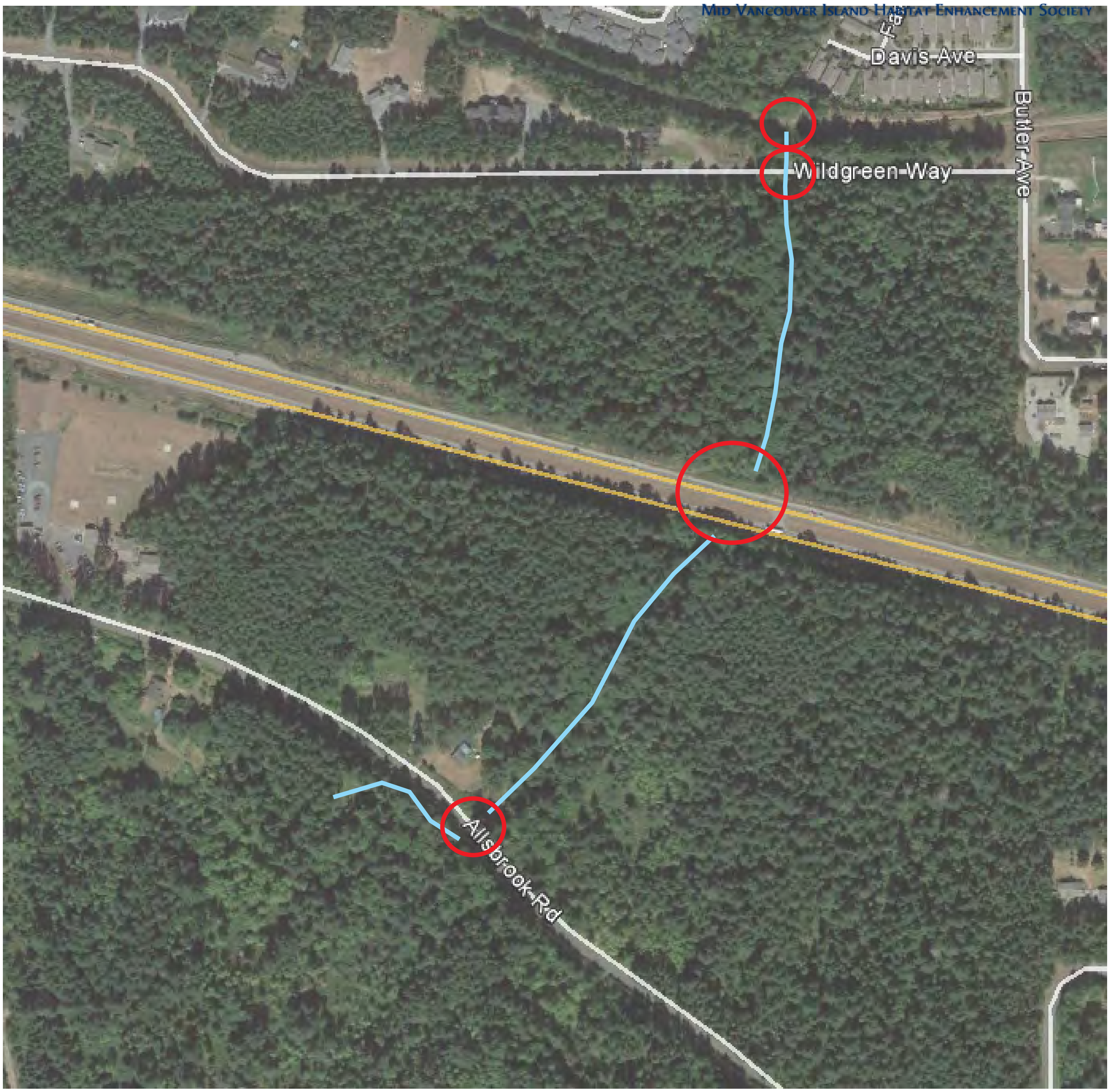
3.6 Grade Control - Channel Stabilization

Limited access and steep terrain will increase the costs of stabilizing Reach 3, often referred to as the Canyon Reach. Due to the obvious difficulties the stabilization of this reach through in stream works should only be undertaken if the process of naturalizing the upper watershed cannot be accomplished. The location of the potential stabilization is shown on **Figure 3-11**.

There are numerous structures that can be utilized to reduce the erosion in Reach 3. Several are shown on **Figure 3-12** and include:

- rock lined channels or stone chutes,
- a series of rock weirs, and
- a series of log check dams.

The planning process needed for these structures will include conceptual designs to establish comparative cost estimates followed by detailed design to finalize the location, sizing, details, and costs for construction.



Culvert Location

Shelly Creek Watershed Plan

Grade Control - Channel Stabilization

Figure 3 - 11

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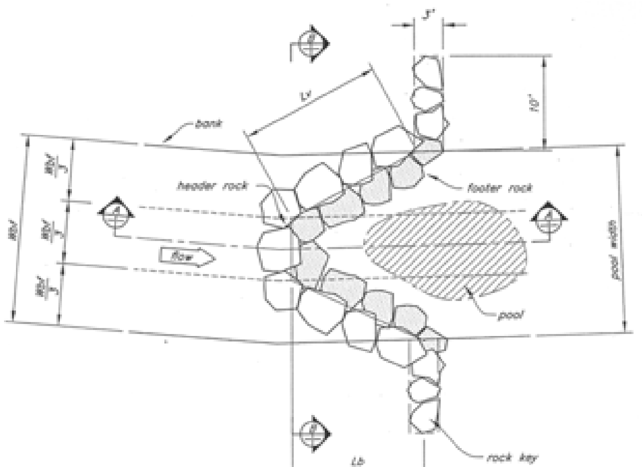

Rock Weirs

Stone Chute

Log Check Dam

Log Weir Structures

Constructing Log Check Dam

Shelly Creek Watershed Plan

Grade Control Structures

Figure 3 - 12

4. DEVELOPMENT PROCESS

The process of land development and changing land use is not well understood by the public. Creation of a successful mitigation strategy for the Shelly Creek watershed must begin with an understanding of the process of land development for both rural and urban subdivisions in British Columbia.

A review of the development process will provide insight into the difficulties in implementing a mitigation strategy for the watershed and how the current processes must be changed to allow restoration of Shelly Creek. A more in depth description of the Land Development Process in British Columbia can be found in the following document: http://waterbucket.ca/wp-content/uploads/2012/05/4_Primer-on-Land-Development-Process-in-BC_September-2013.pdf

The Land development in British Columbia follows a legislative and regulatory framework that allows property owners to build in accordance with existing zoning or to apply to the local government having jurisdiction for changes to land use and density of use through rezoning processes and then to subdivide the property in accordance with applicable zoning and other development related bylaws and requirements. This results in smaller lots that can be sold to others with the intent of constructing buildings upon the individual lots.

The process of development can be divided into the following general topics:

- Land Use Zoning
- Subdivision
- Bare Land Strata
- Results of Subdivision

The development of rural subdivisions is similar but different than land development within urban or areas. The differences relate to the regulatory and approval processes that affect the standards for design and construction

4.1 Rezoning of Land

The rezoning process includes a comprehensive review of many technical issues. A local government must be satisfied that the public will be served by allowing a change in the land use zoning. The rezoning process addresses such issues as the serviceability and access to the new properties. For rural and urban areas, the review provides assurance that there would be sufficient potable water, a way of disposing of sewage, ready public access to the properties and that no significant natural hazards exist that would endanger the public or properties. The rezoning process does not directly result in a subdivision or the authorization to construct a development on the resulting parcels. The process of subdivision is initiated with reference to applicable zoning, which in the case of rezoning, the subdivision process would follow the approval of the rezoning application.

At present there is no requirement for environmental mitigation. The rezoning process can be modified by the RDN and the City of Parksville to include the implementation of the recommended mitigation plan.

4.2 Subdividing of Land

Subdividing is a complex process involving many overlapping interests and regulatory requirements. In British Columbia, a person may divide his or her property into smaller parcels and register them with the Land Title & Survey Authority. Before such a subdivision plan can be registered, however, the Land Title Act, Strata Property Act, Real Estate Development Marketing Act and Local Government Act of British Columbia require an official known as an Approving Officer to approve the plan. Every subdivision must be approved by an Approving Officer appointed under the Land Title Act.

The subdivision process yields bare lots that have utility services and road access to their property boundaries. Including rainwater management systems into the municipal Rights-Of-Way and dedications can be undertaken as part of the subdivision process in providing municipal infrastructure. The RDN, MOTI, and the City of Parksville must revise their design standards to include the rainwater management systems necessary to mitigate the impacts in the Shelly Creek watershed.

Following subdivision with the creation of bare serviced lots the land developers and their respective consultants have completed their obligations and are released from further responsibilities.

4.3 On-Lot Construction

A vast majority of the newly created properties are sold to new owners who would then complete the development process. The building construction is the final step in overall process where the property owner applies for a building permit to construct a dwelling.

Design and construction of on-lot rainwater management systems would occur following subdivision. The two most significant reasons for this sequence are described below.

1. The first reason is to establish the building location within the building envelope to allow sufficient clearance and to avoid conflicts between the location of the building and the various components of the rainwater management system.
2. The second reason is that subdivision creates serviced lots without any provision for on-lot construction. The latter must meet building code provisions, and municipal staff carry out inspections at specific points during construction.

The RDN, and the City of Parksville must revise their building permit standards to include the rainwater management systems necessary to mitigate the impacts in the Shelly Creek watershed.

4.4 Implementing Rainwater Management

Implementing rainwater management systems is a good and environmentally sound decision in any local government. The aesthetics and livability of neighbourhoods and communities can be enhanced while allowing development and protecting the environment.

Inclusion of rainwater management can be a complex regulatory issue in light of how land development occurs and the responsibilities of the individuals and firms which are a part of the process. The actual process of implementing rainwater management requires that the local government establish watershed targets, design guidelines and provide clarity on whether the infrastructure would be constructed within Rights-Of-Way, on private property or distributed.

The rainwater infrastructure constructed within Rights-Of-Way requires review and approval of the local government and MOTI in rural areas. The infrastructure could be constructed as part of the servicing of the subdivision and prior to the sale of individual lots.

Rainwater infrastructure which is to be constructed on private property would require design review and inspections by a suitably qualified professionals and / or building inspectors as part of the building process and regulated under the building permit process.

Alternatively a new administrative process of design, review, approval and acceptance may be created by the local government. A modified process may include a qualified professional for design and certification. Inclusion of a qualified professional would necessitate modification of the Development Agreements and the legal relationships between the local government, the developer, the home builder and the engineering consultants that have been a standard part of the land development process to date in other jurisdictions.

Thus, the Land Development Process would require a balance of enforceable regulation provided through Bylaws and Administrative process that would allow a bridge to be formed between the two steps of the Land Development process which are comprised of Subdivision and Building Construction.

5. CORPORATE AUTHORIZATION

This document entitled:

Shelly Creek Water Balance
and
Sediment Reduction Plan

Phase 2 – Computer Modelling and Assessment

Client Name:
Mid Vancouver Island Habitat Enhancement Society

Was prepared by:

J.M.K. (Jim) Dumont, P.Eng., P.Ag.

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June 23, 2017

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