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ACKNOWLEDGEMENTS

Preparing a master drainage plan requires a team effort. While the Consultant guides the process, each team member makes a significant contribution to one or more of the following areas:

- Gathering information about existing infrastructure (as-builts and field reconnaissance)
- Understanding existing hydrology (anecdotal and recorded information)
- Gathering and preparing base information (mapping, ortho photos)
- Projecting future land use (locations, types, amounts)
- Establishing objectives, guiding principles, and criteria
- Obtaining operational and climatic data (stream flows, rainfall, lake levels)
- Quality control (document and data reviews)

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EXECUTIVE SUMMARY

1.0 Introduction

This *Master Drainage Plan* was commissioned by the District of Summerland to:

- Identify projects that should be included in the District's capital works plans with respect to improving stormwater management.
- Evaluate the impacts of projected development with respect to drainage, and to provide guidance for the development review process.
- Develop and recommend appropriate strategies for managing runoff from anticipated development.

The work was commissioned in two phases:

Phase 1 Preparing a MDP for the Prairie Creek basin – completed in 2006.
Phase 2 Preparing a MDP for the remainder of the basins (Bentley Road, Eneas Creek, Front Bench, Giants Head, Kevin Brook, and areas bordering Okanagan Lake and Trout Creek) – completed in 2009.

This document was structured to allow the documentation for the Phase 2 basin plans to be added to the *Master Drainage Plan* as they were completed. For the most part, this has been accomplished. There are some differences in style and content between the Phase 1 and 2 drawings and tables. These are due to:

- an effort to improve the clarity of the information shown,
- use of different modeling software (resulting in different types of output data), and
- development of unit runoff rates to simplify the development review process.

In addition to collecting information about existing drainage, computer modeling was conducted to help quantify potential impacts of projected development. Existing conditions were first modeled to ensure that the models reflected historical conditions reasonably accurately, then future conditions were analyzed using both low-impact development (LID) as well as conventional techniques for managing rainfall runoff.

2.0 Issues, Policies, and Guiding Principles

Several key issues which are complementary to the *Master Drainage Plan* are included for information and discussion purposes. It is hoped that if not already policy, the associated recommendations would be considered for adoption by the District of Summerland as part of its overall stormwater management strategy. These are as follows:

- Since the long term Ministry of Environment plan is to regulate stormwater discharge to receiving waters, the District should encourage and support the use of structural Best Management Practices where feasible. Planning and policy documents should also promote stormwater management systems that improve runoff quality. Failure to initiate these practices may result in significant future upgrade costs.
- The District should ensure that the Riparian Area Regulation (RAR) process is applied in all stormwater management activities where applicable.

  Note that in a February 6, 2006 memo to Mayor & Council from the Director of Development Services, a recommendation was made to amend the Zoning Bylaw to include Okanagan Lake to the list of watercourses requiring minimum setbacks. This indicates that Council and Staff are aware of, and support the RAR process.
- If a proposed development is located, even partially, within an area with a known or suspected high groundwater table, a site-specific groundwater investigation should be required as part of the development application review process. This investigation should identify groundwater conditions and recommend specific measures to mitigate potential problems.
- Where conditions appear favorable to implement in-ground stormwater disposal systems, a site-specific hydro-geological investigation must be completed by a Professional Hydro-geologist as part of a development's Stormwater Management Plan. If suitability is confirmed, then an in-ground disposal system should be designed and constructed based on the recommendations of the hydro-geological report. The report should address projected life span and maintenance costs of the proposed system.
- Whenever in-ground stormwater disposal systems are considered for use within a development, or whenever there is potential for significant amounts of surface water to be concentrated prior to infiltration, the issue of groundwater-induced slope instability should be adequately addressed as part of the development application review process.
- The District should revise the subdivision bylaw to include more specific requirements for a detailed lot grading plan. It should also revise the building permit process to include compliance with the lot grading plan as a requirement of the building permit.
- The District should develop an immediate plan to proactively address Priority 1 deficiencies. Priority 2 deficiencies should be proactively addressed when and if they are impacted by

proposed development. Priority 3 deficiencies could be proactively addressed as part of other capital works projects, or reactively addressed if and when conditions require action.

- Develop a policy which defines the conditions under which mitigative measures should be implemented. Also develop and implement a systematic plan to address the following for each identified unplanned emergency drainage route:
  - evaluate risk in terms of design flow, frequency, and potential damage
  - identify mitigative options
  - assign priorities
  - include highest-priority works in the annual maintenance budget
  - develop a method of collecting funds for this specific maintenance issue
- District Staff should develop the habit of consulting the Master Drainage Plan whenever a triggering event (development applications, routine maintenance by the District, planned road or utility upgrades, or mitigation of persistent or significant system failures) occurs. They should also use the Master Drainage Plan to define projects for capital expenditure and annual maintenance plans. The Master Drainage Plan should be considered as a current reference document. It is formatted to facilitate continual updating, and should be updated whenever new information develops. Completed projects should be noted as such.

Key guiding principles upon which the *Master Drainage Plan* has been developed are as follows:

- The District of Summerland uses dual drainage systems – the minor system for convenience purposes, and an emergency system for protection when the minor system fails. In the *Master Drainage Plan*, primary emergency drainage routes (also known as overland flood route) and associated structures are identified. Future development should respect these routes and incorporate them into their plans. Where the primary emergency drainage system within a developed area proves to be inadequate, the *Master Drainage Plan* identifies and recommends appropriate corrective actions.
- In the *Master Drainage Plan*, piped emergency drainage routes are proposed only when surface drainage routes are not feasible.
- In addition to protecting life and property, stormwater management should also ensure that natural water resources are protected from erosion, sedimentation, pollutants, and source depletion.
- Low impact stormwater management strategies should be used wherever feasible. Conventional drainage systems should be allowed only when low impact methods prove unfeasible. However, if conventional systems are to be implemented, appropriate measures should be taken to mitigate potential negative downstream impacts.

- The impacts of introducing irrigation water to a new development, or initiating irrigation on previously dry land, should be identified. Where there is a high potential for this to negatively impact downstream properties, mitigative measures should be incorporated into the development design. In the case of newly-irrigated agricultural land, an irrigation management plan should be prepared to minimize potentially negative impacts.

3.0 Design Criteria and Assumptions

Of the many design criteria and assumptions outlined in **Section 3** of this document, the definitions used to classify project priorities are of particular importance with respect to items referenced within this Executive Summary. These are as follows:

Priority 1 — This priority applies to proposed projects which are considered necessary to prevent significant damage to both public and private property and/or danger to the public from runoff generated under *existing* development conditions.

Priority 2 — These proposed projects are considered necessary to prevent:

- inconvenience or annoyance from runoff generated under existing development conditions, or
- significant damage to both public and private property and/or danger to the public from runoff generated under future development conditions.

Priority 3 — These proposed projects are considered necessary to meet identified standards, but failure to meet these standards is unlikely to cause:

- significant inconvenience from runoff generated under existing development conditions, or
- significant damage to both public and private property and/or danger to the public from runoff generated under future development conditions.

Proposed works classified as a Priority 3 may be postponed until future development occurs.

4.0 Analyses

Three sets of analyses were completed for each of the primary drainage basins as follows:

- Existing development with existing drainage systems. This is to identify existing deficiencies and develop a baseline for evaluating impacts by future development.
- Proposed development with low impact drainage systems. This allows the District to consider the effectiveness and benefits of employing low impact stormwater management methods.
- Proposed development with conventional drainage systems. This is to determine the level of upgrades and new works necessary to service projected development if conventional stormwater management methods only were considered. This information provides a basis for comparison to potential low impact stormwater management methods.

An analysis of the unit runoff rates for areas under both existing and low impact development (LID) conditions was also conducted. It was found than under existing conditions, even with the 100 year design storm, runoff from natural, undeveloped areas often is zero. Under LID conditions, the average 100 year unit runoff for the selected areas was just under 1 Lps/ha. Therefore, the following unit rates were recommended establishing allowable discharge rates from future development sites:

- 0.5 Lps/ha for the minor system discharge (up to the 10 year design rainfall event), and
- 1.0 Lps/ha for the major system discharge (up to the 100 year design rainfall event).

5.0 Basin Drainage Plans

In the *Master Drainage Plan*, this section presents the interpretations, options, proposed works, and estimated capital costs associated with each of the primary drainage basins within the study area. This extensive information is summarized below except for the capital costs. These are summarized in the following section.

<u>Prairie Creek Basin</u>

Area: 1390 ha

Description: The second largest drainage basin in the District, Prairie Creek basin is comprised of almost equally of natural landscape, agricultural lands, and a mix of residential, commercial, and industrial development. Dispersed throughout the agricultural land is rural residential development.

Several large development sites have been identified in the western and northern part of the basin, as well as some smaller developments to the south off Victoria Avenue. In some areas, development proposals have already been submitted.

Drainage: Prairie Creek forms the primary major drainage route for this basin. Much of its base flow is generated by leakage from the Trout Creek water reservoir. The channel is well defined and stable, but becomes severely constricted by development after it crosses Prairie Valley Road at Phinney Avenue. Approximately 1.6 km of this stream is piped through the lower half of the basin. Only portions of the downtown area are serviced by urban-section roads and associated storm sewer systems which eventually discharge to Prairie Creek. Most of the residential development is serviced by rural-section roads with no drainage infrastructure. This ensures that Prairie Creek is relatively unaffected by runoff from rainfall events.

Analysis indicates that Prairie Creek does not have the hydraulic capacity to accommodate increased runoff from the projected developments, and because much of it has become somewhat naturalized, it is not considered feasible to increase the channel capacity. These capacity issues are exacerbated by winter ice build-up, which is an on-going operational issue. Since the capital cost of constructing several kilometers of trunk storm sewer to service these development areas is considered too expensive, significant on-site controls for runoff up to the 100 year conditions will be required.

Projects: Eleven capital projects and a geotechnical study were recommended. Two projects are Priority 1, nine are Priority 2, and one is Priority 3.

Project PV5 consists of piped bypass on Prairie Valley Road from Phinney Avenue to Brown Street. It is a high priority because the existing Prairie Creek channel has insufficient capacity to accommodate existing 100 year peak flows.

Project PV8 is comprised of a geotechnical study to evaluate the risks of and impacts associated with the failure of the silt bluff along Prairie Creek between Highway 97 and Butler Street.

The Priority 2 projects were recommended because of potential impacts from future development. The single Priority 3 project addresses drainage for an area west of the downtown which might eventually redevelop, but is not currently considered a development area.

Bentley Road Basin

Area: 290 ha

Description: The Bentley Road Basin consists primarily of undeveloped and agricultural land. It is almost bisected by Highway 97, with a significant intersection at Bentley Road. A pocket of industrial development is located near this intersection. The rest of the existing development, however, consists of rural residential and a portion of a golf course with low density residential.

The western half of the catchment contains most of the residential development projected on Rattlesnake Mountain. One other small development within the southern part of the basin is also identified, but it is already being constructed.

Drainage: A piped system drains the Bentley Road and Highway 97 intersection. It also forms the major drainage route for the portion of the basin located on the western side of the highway. This system discharges into a natural ravine which contains a small wetland on private property. The ravine then drains to Okanagan Lake via a pipe at the west end of N. Lakeshore Dr.

Analysis indicates that the existing piped drainage system has sufficient hydraulic capacity to accommodate projected peak flows from potential development, but not without severe impacts to the natural ravine and wetland. It is recommended that future development implement on-site controls for up to the 100 year conditions.

Projects: Two Priority 3 projects were recommended to improve major drainage route definition and connectivity.

Lakeshore Basin

Area: 209 ha

Description: The Lakeshore Basin is comprised mostly of agricultural land, with pockets of residential and industrial development in the Jones Flat area. It also contains relatively unstable silt bluffs along the lake shore.

No development was projected within this basin. However, twelve projects were identified.

Drainage: This basin is a collection of many smaller catchments which drain directly to Okanagan Lake between the Bentley Road Basin outlet and Eneas Creek. Natural topography forms the major drainage routes, but these are intersected by several rural roads. Except for a few culverts across N. Lakeshore Dr. and Highway 97, there is little other existing drainage infrastructure within this basin. In general, this has not been a problem. However, poor runoff control on a recently constructed vineyard did cause runoff to cascade over the silt bluffs and through several existing homes along the lake shore in July, 2007.

Projects: Twelve Priority 3 projects were recommended for this basin to improve major drainage route definition and connectivity.

Eneas Creek Basin

Area: 2770 ha

Description: Eneas Creek is a perennial creek flowing from an overflow control flow structure at Garnet Lake. Although this is the largest basin in Summerland, it is comprised mostly of natural and agricultural lands. Low to medium density residential development is located just west of Highway 97 and along the lake shore. There is a pocket of industrial development near Logie Road, and commercial development along the western side of the highway. The rest of the existing development is comprised of rural residential.

Several small infill developments are projected within the lower portion of the basin, but a large potential residential development is located on Rattlesnake Mountain.

Drainage: Eneas Creek forms the major drainage route for this basin. However, urban-section roads, rural ditches, and natural ravines are tributary to it. The creek channel becomes constricted by existing development just west of Garnet Avenue, and remains so until it passes under Highway 97. On the east side of the highway, the creek flows within a deep ravine until it enters Okanagan Lake. While it passes through many private properties within this lower reach, the channel is relatively well defined, stable due to vegetation, and serviced by relatively large-diameter culverts.

There is a significant amount of storm sewer infrastructure within the area east of the highway, bordered by Eneas and Prairie Creeks. These discharge to Okanagan Lake in four locations. Most of the existing culverts are located either on Eneas Creek or along the highway.

Projects: Fifteen projects were identified for this basin – one Priority 1, six Priority 2, and eight Priority 3. The Priority 1 project is EC-06, and is comprised of installing a piped drainage route from the cul-de-sac on Bristow Road to Eneas Creek. This project, along with three of the Priority 2 projects, address drainage system failures which occurred during the

July, 2007 rainfall event. The rest of the projects address either minor deficiencies or proposed development.

In addition to these specific projects, on-site controls for the 10 year runoff conditions should be adequate for the infill developments. The Rattlesnake Mountain development, however, should control up to the 100 year runoff conditions in order to protect the Eneas Creek channel from erosion. Also, The four existing drainage systems which discharge to Okanagan Lake, should be equipped with units to improve stormwater quality. This can be done as part of the annual capital expenditure program.

Front Bench Basin

Area: 266 ha

Description: The Front Bench Basin is bounded by Giant's Head Mountain to the west, Highway 97 to the north and east, and a drainage divide to the south. It is comprised of a mix of natural landscape, some agriculture, and a significant amount of low density residential development.

Most of the anticipated future development within the basin was under construction during preparation of the *Master Drainage Plan*.

Drainage: Most roads within this basin have rural cross sections, but a few of the developments have curb & gutter. Therefore, several storm sewer systems exist. These are relatively short, however, and were constructed primarily to direct runoff to a rural ditch or natural ravine. A few may have also been constructed to drain areas subject to ponding.

Despite the existence of these systems, runoff seems to infiltrate into the ground before it reaches the silt bluffs along the western side of Highway 97. As long as roads remain rural, and no further development occurs, this should be fine.

The area identified as future development (Walters Road) will be required to install a piped system that must ultimately be extended to the base of the silt bluffs.

Projects: Twelve projects were identified for this basin – one Priority 1, three Priority 2, and eight Priority 3. The Priority 1 project FB-05, a storm sewer from Jewel Place to the ditch along Highway 97, is urgent because of flooding experienced during the July, 2007 storm. The capital cost of this project would be shared with future development along Walters Road. Two Priority 2 projects are also recommended to address deficiencies revealed by this rainfall event, but their implementation is less urgent.

The Priority 3 projects are recommended to improve major drainage route definition and connectivity.

Giants Head Basin

Area: 209 ha

Description: The Giants Head Basin is located on a plateau above the silt bluffs west of Highway 97. It is comprised of the steep, rocky slopes of Giants Head Mountain, a significant amount of agricultural land, and pockets of low-density and rural residential development.
A small amount of development is projected along the base of Giants Head Mountain.

Drainage: This basin is drained by a series of large ravines which collectively form Zimmerman's Gulch. It ultimately discharges to Okanagan Lake via a 600mm culvert that crosses the highway. Drainage infrastructure consists of culverts and short lengths of pipe which either cross roads or drain low points subject to ponding.

The July, 2007 storm caused damage to an existing property located on a major, but un-recognized drainage route across Giants Head Road. This issue must be addressed prior to allowing the upstream development to occur. It is also recommended that future development implement on-site controls for up to the 100 year conditions.

Projects: Nine projects were recommended for this basin. Three are Priority 2 while six are Priority 3.

Project GH-05 is recommended to improve the major drainage route impacted by the July, 2007 storm. It was not classified as a Priority 1 since the impacted property owner has already made some provisions for future flows. Half of the capital cost of this project could be allocated to future development. The other Priority 2 project (GH-08) also addresses deficiencies revealed by the July, 2007 storm.

The Priority 3 projects are recommended to improve major drainage route definition and connectivity.

Lake Front Basin

Area: 185 ha

Description: Predominantly flat, and bisected by Highway 97. Some commercial development is located along the highway, but the basin contains mostly agricultural land with pockets of low-density residential development. The lake shore is now fully developed (including current construction) into low-density residential. No other future development was identified.

Drainage: Although most rainfall infiltrates into the ground, runoff from the western half of the basin would flow to the highway via numerous, poorly-defined routes. Two culverts cross the highway, but there is no evidence of active drainage routes downstream of them. The roads mostly have rural cross-sections, but there are two small piped drainage systems which, presumably, were constructed to drain areas of ponding.

Projects: Only two Priority 3 projects were identified. Both are related, and are located along Gartrell and Arkell Roads. They were recommended to address undersized culverts and poorly-defined ditches. In addition, the existing piped drainage systems should be equipped with units to improve stormwater quality since they discharge directly to the lake. This should be done as part of an on-going annual program.

East Trout Creek Basin

Area: 65 ha

Description: Entirely flat, this basin is bisected by Highway 97, bordered by Trout Creek to the south, and Okanagan Lake to the east. Some commercial development is located along the highway, but the western half is mostly agricultural land while the eastern half is almost all low-density residential. Two pockets of future single family and medium density residential development have been identified.

Drainage: If and when surface runoff occurs within the western half of the basin, it will either drain directly to Trout Creek, or to the ditch along the highway, which also drains to Trout Creek. Within the eastern half of the basin, all of the roads have rural cross sections. There are four small storm sewer systems that discharge directly to the lake, which presumably, were installed to address ponding issues.

A small portion of a proposed development area on Giants Head could drain into this basin, however, the anticipated impacts are small.

Projects: No specific projects were recommended for this basin. With adequate on-site controls, runoff from the projected developments should be able to utilize existing systems. The four existing drainage systems, however, should be equipped with units to improve stormwater quality. This should be done as part of an on-going annual program.

South Trout Creek Basin

Area: 136 ha

Description: This basin forms a high-plateau fan from the base of Giants Head Mountain. It is bordered along the south by Trout Creek, and is comprised of agricultural land and sparse rural residential and agri-commercial development.

Drainage: Ditches along the rural roads and the Kettle Valley railway form the major drainage routes. These eventually drain to two primary routes which drop over the steep bluffs above Trout Creek. Because of the rural nature of the basin, surface runoff rarely occurs, and there is no evidence of surface flows over the bluffs.

Projects: Six projects were recommended – one Priority 2 and five Priority 3. While all of the projects are intended to improve drainage route definition and connectivity, ST-01 is classified as a Priority 2 because it is partially required to service future development.

Kevin Brook Basin

Area: 515 ha

Description: The topography of this basin varies from mountainous to flat plateau, and is comprised mainly of natural and agricultural lands. Pockets of industrial and low-density residential development are located near the basin's northern boundary, but sparse rural residential development is scattered throughout.

Several large low and medium density residential development areas have been proposed.

Drainage: Kevin Brook forms the major drainage route to Trout Creek. However, ditches and swales along the rural road network form tributaries to this route. A network of storm sewers service the industrial and residential developments within the northern part of the basin. These eventually discharge to Kevin Brook.

Because Kevin Brook would be severely damaged by significant increases in flow due to runoff from the projected developments, and the capital cost of constructing several kilometers of trunk storm sewer is considered too expensive, significant on-site controls will be required to ensure it is protected. This includes controlling the 100 year post-development discharges.

Projects: Ten projects were identified for the Kevin Brook Basin – Four Priority 2 and six Priority 3. The Priority 2 projects are required to service future development while the rest are recommended to improve existing major drainage route definition and connectivity.

West Trout Creek Basin

Area: 400 ha

Description: Almost all of this basin is comprised of steep, natural land with a pocket of agricultural land near its center. While there is some sparse rural residential development within the north-eastern half of the area, the only other significant development is a golf course.
Three low and medium density residential development areas have been identified within this basin.

Drainage: There is no evidence of any significant surface runoff from the West Trout Creek basin. However, the natural topography forms several major drainage routes to Trout Creek – all of which plunge over steep bluffs. A couple of these routes are intercepted by rural roads, but no drainage infrastructure currently exists.

Since the bluffs could be severely eroded if exposed to significant and frequent flow events, runoff from proposed developments must be controlled on-site up to the 100 year conditions.

Projects: Two projects - one Priority 2 and one Priority 3 - were recommended for this basin. While both consist of ditching and culverts to improve major drainage route definition and connectivity, one will service future development.

6.0 Capital Costs

Table 6.1 summarizes the following items for each proposed capital project:

- estimated capital cost (includes 15% allowance for engineering, and 25% allowance for construction contingencies)
- assigned priority, and
- allocation to existing deficiency and/or future development. (This information can be used by the District to develop a capital cost recovery strategy.)

Note that in most cases, the estimated capital costs for works proposed under low impact development (LID) and conventional systems conditions are identical. This is due to the assumption that larger development areas (Rattlesnake Mountain and Jersey Lands, for example) which are several kilometers from receiving waters, must implement on-site controls to attenuate their post-development, 100 year peak flow rates to at least that which might be obtained using LID principles. This allows the developer to decide how to manage their stormwater on-site – either through LID techniques, or with conventional systems. In both cases, however, the downstream requirements should be similar.

In addition to the listed capital costs, the District should budget at least $100,000 per year to install stormwater quality enhancement units on existing piped drainage systems which discharge to Okanagan Lake.

7.0 General Conclusions and Recommendations

Conclusions

1. Based on the events of the July, 2007 rainfall event, agricultural and natural, undeveloped lands have sufficient storage capacity to absorb most of the rainfall delivered by storms with return periods of up to 100 years.
2. Most of the existing major drainage systems have sufficient capacity to accommodate runoff under existing development conditions.
3. Many of the existing piped drainage systems which discharge directly to Okanagan Lake, are not equipped with units to improve stormwater quality.
4. Existing major drainage systems, can, in general, accommodate anticipated runoff from the few, small, infill developments currently identified.
5. Use of conventional drainage systems to service large developments located a significant distance from Okanagan Lake or Trout Creek (receiving waters), is considered economically infeasible.
6. The District requires new developments to attenuate post-development flows to pre-development levels. However, the current methods used to establish pre-development peak flows were

developed for design purposes, and therefore yield conservatively higher values than what would be normally observed. This means that existing drainage systems downstream of new development are often subjected to increased flow rates even though the intent was to control post-development flows to pre-development levels. In some cases, this has created - or will create, downstream capacity deficiencies and unanticipated upgrading requirements.

7. Low Impact Development (LID) methods can reduce or eliminate the need for significant downstream drainage improvements.
8. Stripping land of its natural or planted organic layer without adequate measures to ensure potential runoff is managed, can and does result in downstream impacts.

Recommendations

1. For developments required to attenuate post-development runoff to pre-development levels, implement a simplified method of establishing the allowable (pre-development) flow rate using the following unit runoff rates:
   a. 0.5 Lps/ha for 10 year events or less (minor system)
   b. 1.0 Lps/ha for up to 100 year events (major system)
2. Since the LID techniques reduce peak flows, provide some capital cost savings, and promote better stream health, the District should take the steps necessary to ensure that they are implemented in future developments and re-developments.
3. Where it is not feasible to upgrade downstream drainage systems to accommodate runoff from future development, ensure that on-site controls or methods are employed to attenuate the 100 year post-development flows to the allowable 100 year discharge rate as calculated using the unit runoff rates outlined in Recommendation 1.
4. Ensure that under the proposed District Earthworks bylaw, adequate provisions are made to manage any potential runoff from areas which are to be stripped of the organic topsoil layer.
5. This document is intended to facilitate annual capital works planning and budgeting. Since triggers and priorities have been identified for each project, District Staff should review the projects annually and select the ones which should be included in the next Capital Works Plan. In some cases, the identified projects could be divided into phases that can be implemented over several years.
6. In order to address existing deficiencies with respect to the quality of stormwater discharged to Okanagan Lake, the District should budget at least $100,000 per year to install stormwater quality enhancement units on existing piped drainage systems which discharge to the lake.
7. Because the proposed projects have been organized geographically, it is relatively easy to identify any drainage projects that should be implemented because of other activities within the study area. Therefore, when road or utility upgrades are being considered, or when development

proposals are submitted, Staff should refer to this document in order to determine if any of the projects are required or should be implemented.

8. This document will become out-dated quickly unless Staff keeps it updated. Because of the way it is organized, Staff should remove the project sheets for projects which have been completed, and replace them with a reference to as-constructed drawings. Staff should also make notations to project sheets when the circumstances surrounding a project change.

9. While the paper copy of this document is valuable as a reference and guide, there is a significant amount of corresponding data available electronically for the drainage catchments and systems within the study area. These data include design flow rates, physical characteristics, and performance metrics for both the existing and proposed drainage infrastructure. These should be referenced when more detail than that contained in this document is required.

1.0 INTRODUCTION

The purpose of this document is to provide a framework within which stormwater management decisions can be developed and implemented with confidence by the District of Summerland. Many factors impact how runoff from rainfall and snowmelt events are accommodated and managed to ensure the safety of people and to protect the use and enjoyment of their property. Rainfall and snowmelt, however, are also natural resources upon which local flora and fauna depend. Natural streams and wetlands are not only home to many plant and wildlife species, they also provide amenities which are enjoyed and appreciated by residents and visitors alike. These natural resources reflect part of the health and balance of the community, and provide quality of life values that many would agree are worth protecting.

While the term *Master Drainage Plan* infers only a narrow scope – how to effectively drain runoff from rainfall and snowmelt events – the current document reflects a much wider and inclusive scope. Although drainage is important, other values are considered in this document. This is discussed in more detail in **Section 2**.

1.1 Background

In 1995, the District commissioned UMA to prepare a *Storm Drainage Study*. This was a general overview of drainage within the District, and while it contains some useful information and identified some key improvements, more detail was required. This was especially true within the Prairie Creek Basin, and one of the report's recommendations was that "*No further development should take place within the Prairie Valley basin until a Master Drainage Plan is developed …*".

In 2004, the District of Summerland decided to commission the preparation of this *Master Drainage Plan* due to new development applications and planned road/utility upgrades within Prairie Valley. The capital works budget identified several projects for completion in the near term which included both road and drainage upgrades. Before designing these projects, however, Staff recognized that the proposed works should be sized to accommodate future impacts if applicable.

Urban Systems Ltd. was commissioned to prepare this Master Drainage Plan in the summer of 2004. Although the District intends to prepare a *Master Drainage Plan* for the entire area within its boundaries, it was decided for a variety of reasons that a phased approach would be implemented. Therefore, this document is organized in such a way that plans for additional basins can be added at a later date. The first basin considered is the Prairie Creek Basin, completed in 2006.

In July of 2007, the District commissioned completion of the *Master Drainage Plan*. This second phase included all of the drainage basins within District boundaries excluding Prairie Valley. Referring to **Figure 1.1**, this included:

- Bentley Road
- Eneas Creek
- Front Bench
- Giants Head
- Kevin Brook
- Trout Creek (divided into South, West, and East catchments)
- Lakeshore
- Lakefront

1.2 Objectives

The following objectives were developed in conjunction with District Staff:

1. Confirm and update drainage structure inventory.
2. Confirm basin boundaries and existing drainage.
3. Prepare dynamic hydrology and hydraulic models of the basin's catchments and systems to:
    a. confirm existing deficiencies,
    b. identify potential impacts of proposed development, and
    c. evaluate the effectiveness of proposed management strategies.
4. Develop appropriate management and/or mitigation strategies for the identified existing and potential deficiencies.
5. Estimate capital costs, identify triggering conditions for implementation, and outline an implementation strategy for each set of recommended works.

In Phase 2, the objective of providing pre-development unit runoff rates for areas subject to future development was also added. In order to do this, different software (GSSHA by the US Corp of Engineers) was used to model the hydrology of each Phase 2 catchment. Therefore, unit pre-development flow rates were not provided for development areas within the Prairie Valley basin.

1.3 Document Organization

This document is organized to support the review and planning functions executed by District Staff on a day-to-day basis. Since much of this activity is focused on individual re-zoning or development applications, the information is organized by geographic location. This ensures that all of the information required to conduct an efficient and effective review are grouped together in the document.

Sections 2 and 3 present concepts and data relevant to the entire study area. This includes design criteria, objectives, methodologies, and other general discussions. **Section 4** discusses the analyses that were completed and sets the context for the stormwater management concepts presented in **Section 5.**

Section 5 focuses on issues that are better understood within the context of individual drainage basins. Each basin-based section includes a general description, key land use issues, major drainage, and an overview of proposed improvements. Each section also includes detailed discussions about existing and anticipated system deficiencies, potential improvement options, preliminary capital cost estimates, recommended works, and suggestions for implementation. These detailed discussions, or "project sheets" include all of the information about the proposed works in one location, including design flow, options, estimated capital costs, and construction triggers.

Section 6 summarizes the capital costs associated with all of the recommended works while **Section 7** provides general conclusions and recommendations developed during the course of the plan development.

When Phase 1 of the *Master Drainage Plan* was completed, the intention was to simply add the Phase 2 sections of the document without any changes to the format or document structure. For the most part, this has occurred. There are, however, a few differences between elements of the Prairie Valley basin plan (**Section 5.1**) and the other basin plans. These differences are most evident as follows:

- The Phase 2 drawings use a different layout and display different sets of information. This was done to improve clarity since the Phase 1 drawings contain, in some cases, too much information and are therefore difficult to read.
- The Phase 2 summary tables for sub-catchments and conduits contain more information. Also, there are no Phase 2 junction (manhole/drywell) tables. These changes are due to the type of data used for and generated by the GSSHA model (see **Section 3.2**) used for the Phase 2 analyses. The decision to exclude junction tables was also based on the fact that sufficient as-constructed or field-surveyed data (invert and ground elevations, for example) existed to properly populate them.
- Rather than place the tables and figures in appendices, they have been moved to the end of their corresponding report sections. In this way, all information for a given drainage basin is located in one place.

1.4 Disclaimer

Although this document contains drawings and illustrations showing existing drainage works, they are not intended to be relied-upon as as-constructed information. Most of the data contained on these drawings have been gathered from different sources generated during a span several years. Often, there was no guarantee that the obtained documents were, in fact, the most up-to-date. Nor was there any certainty that other systems hadn't replaced the structures shown in the documents obtained. Initial field reconnaissance was conducted by District Staff to verify major drainage routes within each basin, but it was beyond the scope of this study to confirm each and every drainage detail within the study area.

Therefore, prior to implementing any of the works recommended in this document, field information should be confirmed in greater detail, hydraulic analyses should be updated, and appropriate designs should be prepared based on this updated data.

This document also contains information about soil and groundwater conditions. These data were developed/compiled on a very general basis to provide an indication of potential conditions. Final stormwater management works or decisions contingent upon groundwater and / or soil conditions should be based on site-specific data.

2.0 ISSUES, POLICIES, AND GUIDING PRINCIPLES

2.1 Issues & Policies

This section presents several key issues which are complementary to the *Master Drainage Plan*. They are presented for information and discussion purposes, with the hope that if not already policy, the recommendations would be considered for adoption by the District of Summerland as part of its overall stormwater management strategy.

2.1.1 Stormwater Quality

Issue:

What level of environmental protection does the District of Summerland want to provide with respect to stormwater quality?

Discussion:

The issues surrounding stormwater quality and the impact of urbanization are many and complex. The purpose of this section is to provide an overview of the issues related to stormwater quality and measures available to deal with the challenges. This section has been prepared following a review of available literature and discussions with staff of the Ministry of Environment (MoE) who have regulatory authority with respect to drainage, watercourse, and pollution control issues.

Background:

It has been recognized for some time that land development and urbanization generally have a negative impact on the quality of stormwater runoff. This deterioration results from the following three primary causes:

a) Soil erosion and alteration of riparian areas during construction of urban developments such as residential subdivisions, roads, and municipal infrastructure.

b) Alteration of the hydrology of urbanized watershed, such as an increase in the peak of stormwater runoff, and a reduction of groundwater infiltration and stream base flows.

c) The wash-off of pollutants such as pesticides, herbicides, road sand and salt, among others, after construction of urban developments.

Soil erosion occurs when rain falls on areas which have been stripped of vegetation in conjunction with development. The result can be that stormwater runoff carries many times more suspended solids such as silt and sand than before construction, and this can affect fish and their habitat. The alteration of riparian areas includes the stripping of land and removal of trees and brush within the buffer area around the stream channel. Such alteration can reduce shade cover, shelter, and food sources. Streams and ravines into which storm sewers discharge runoffs from new development are also subject to erosion due to increased flow rates.

Watershed hydrology is affected as a watershed is developed. Under natural, undeveloped conditions, much of the rainfall that occurs within a drainage basin infiltrates into the ground. It moves through the watershed as base flow and minimizes surface runoff. In this way, the ground acts as a reservoir, storing runoff and releasing it over a longer period of time. Following urbanization, there can be a significant increase in the amount of impervious surface which reduces infiltration and causes rain fall to runoff rapidly. The result is lower base flows, and the greater likelihood that smaller streams will dry up between rainfall events.

Finally, following development of an area, stormwater runoff will typically contain a variety of pollutants related directly to urbanization. These may include fertilizers, road sand and salt, herbicides and pesticides, bacteriological pollutants from animal waste, and heavy metals. All of these degrade stormwater quality and affect fish. It is known that most pollutants are contained in what is commonly called the "first flush." This is the initial portion of rainfall which appears as surface runoff. There is no quantifiable limit which defines the end of the first flush, but it is generally accepted that the first few millimeters of runoff contains the majority of pollutants. Therefore, by providing stormwater quality control for the most frequent storms, most of the problem is dealt with.

It has also been recognized for some time that degradation of stormwater quality, or more generally the quality of all runoff, has an impact on fish and fish habitat. Furthermore, fish and fish habitat are both considered valuable resources by the Federal and Provincial governments, and legislation is in place to protect these resources. MoE's concerns are with respect to the protection of the fisheries resource, including both fish and their habitat, recognizing that essentially all watersheds eventually drain to fish bearing streams or water bodies.

It is worth noting that fish habitat consists of several elements. These include cover which provides protection from predators and controls water temperatures, food, substrate which provides spawning areas, water quality, water quantity, and access up and down stream channels.

Regulatory Requirements:
There are a number of agencies involved in the management of stormwater quality. These include federal, provincial and local levels of government as well as non-government agencies. The following is a list of roles and responsibilities of each agency (as of March 2006), which will help to understand how the current system of stormwater management operates.

Fisheries and Oceans Canada (DFO) – Federal
The federal Department of Fisheries and Oceans (DFO) has jurisdiction over all coastal and inland fisheries, except for those which have been delegated to the province. DFO administers the federal Fisheries Act which forms the basis for approvals and enforcement of activities related to fish and fish

habitat. DFO does not have specific legislative authority over the management of stormwater quality, except within the context of the protection of fish habitat.

Environment Canada - Federal
This agency supports a variety of environmental education and stewardship programs and initiatives, along with its enforcement role in pollution prevention. Environment Canada provides environmental standards, as well as monitoring and sampling protocols.

Ministry of Environment (MoE) - Provincial
The provincial government has jurisdiction over Crown lands and all waters within the province. Any stormwater management policies or designs which impact streams, lakes, or other provincial waterways require approval from the MoE. This ministry is responsible for administering the federal *Fisheries Act* where authority has been delegated to the province, as well as a number of provincial Acts including the *Fisheries Act*, *Water Act, Water Protection Act, Wildlife Act, Waste Management Act, Environmental Management Act,* and the *Fish Protection Act.*

Ministry of Transportation (MOT)
This ministry is responsible for constructing, maintaining and administering the provincial highway system as well as local roads outside municipal boundaries. Moreover, all drainage systems situated within the highway corridor are currently the responsibility of MOT. Any proposed drainage systems which feed into, or are situated within the highway corridor, should be managed in conjunction with the Ministry of Transportation.

Ministry of Agriculture and Lands (MAL)
This ministry is responsible for managing farmlands and farming practices. Its activities in relation to stormwater management include: the development of agricultural best management practices, including top-soil conservation; the participation on inter-governmental and municipal committee and task groups; and the development of agricultural runoff control strategies.

Ministry of Community Development (MCD)
This ministry is responsible for administering the *Local Government Act*, and works closely with local government to ensure compliance with provincial regulations. Recent changes to the Act have provided municipalities broader powers to deliver services, and new legislation – notably the provincial *Fish Protection Act* and proposed *Community Charter*, may have significant impacts on the way in which local government operates and provides services.

Ministry of Health (MH)
This ministry has been the lead agency for the province's *Drinking Water Action Plan*, and will develop proposed changes to the *Drinking Water Protection Act*. Included in the discussions to date are the provision of stronger groundwater protection measures, and a "source to tap" protection plan. Any

proposed stormwater quality initiatives by the District should be developed in concert with the current provincial drinking water initiatives.

Okanagan Basin Water Board (OBWB)

The Okanagan Basin Water Board consists of nine regional directors, three each from the North Okanagan, Central Okanagan, and Okanagan Similkameen Regional Districts. Its primary objective is to work with other local governments and regional districts to preserve water quality in the larger lakes of the Okanagan Basin. This Board is administered by the North Okanagan Regional District and looks after funding for waste water treatment facilities and aquatic weed management.

While the Board does not directly deal with stormwater quality issues and objectives, it is expected that any objectives related to improving the water quality in the Okanagan Basin fall within the broad mandate of the OBWB.

Municipal Government

Municipalities have traditionally had the most direct involvement in construction and management of drainage systems, and the level of construction varies from jurisdiction to jurisdiction. Of the three major municipal utilities (i.e. water, sanitary sewer, and drainage), nearly all drainage systems in the province are funded through general taxation, rather than through a separate utility like water and sanitary sewer operations. Moreover, financing of drainage systems improvements through other means (Development Costs Charges for example) tends to command less priority than for other infrastructure improvements (i.e. roads, water and sanitary sewer), and provincial funding is virtually non-existent for drainage projects in comparison to other infrastructure projects.

Best Management Practices:

There are a variety of measures which have been developed over the past few decades and which are shown to mitigate the detrimental impacts of urban development on stormwater quality. These measures are intended to accommodate urban development and while at the same time conserve the fish resource, and are commonly referred to as Best Management Practices (BMP)s.

The measures can be further categorized as structural BMPs and non-structural BMPs. Structural BMPs are defined as measures which generally require the construction of a major facility or some other physical element in the drainage system, such as a detention pond. Non-structural BMPs are non-physical measures such as land use and pollution control bylaws.

Recommendation:

Since the long term MoE plan is to regulate stormwater discharge to receiving waters, the District should encourage and support the use of structural BMPs where feasible. Planning and policy documents should also promote stormwater management systems that improve runoff quality. Failure to initiate these practices may result in significant future upgrade costs.

2.1.2 Riparian Areas Regulation (RAR)

Issue:

The provincial government has stipulated that local governments are responsible for implementing the Riparian Area Regulation (RAR). How will the District implement the RAR and what impact will this have on stormwater management issues?

Discussion:

The Riparian Areas Regulation (RAR) was enacted under Section 12 of the Fish Protection Act in July 2004, and calls on local government to protect Riparian Areas. The purpose of the Regulation is to provide protection for the features, functions and conditions that are vital in the natural maintenance of stream health and productivity. These vital features, functions and streamside area conditions are numerous and varied and include such things as sources of large organic debris (fallen trees and tree roots), areas for stream channel migration, vegetative cover to help moderate water temperature, provision of food, nutrients and organic matter to the stream, stream bank stabilization and buffers for streams from excessive silt and surface runoff pollution.

The RAR applies to 14 regional areas, including the Okanagan-Similkameen within which the District of Summerland is located. The RAR applies to all lands within a local government boundary and all Crown land outside the Provincial forest. It applies to new residential, commercial and industrial development, including ancillary activities, which fall under local government powers under Part 26 of the Local Government Act, to ensure that proposed activities are subject to a science-based assessment conducted by a Qualified Environmental Professional. The RAR does not apply to agricultural activities (which are covered under the Farm Practices Protection Act). Also, the RAR does not apply to a development permit or development variance permit issued only for the purpose of enabling reconstruction or repair of a permanent structure described in section 911 (8) of the Local Government Act if the structure remains on its existing foundation.

Local governments will be responsible for implementation and enforcement of the regulations through a variety of implementation tools including:

- Official Community Plans
- Development Permit Areas
- Zoning bylaws
- Subdivision bylaws
- Development approval and information bylaws
- Covenants
- Other regulatory bylaws affecting land use

- Information and education programs about stream stewardship, watershed or "integrated storm management" plans
- Parkland acquisition
- Tax incentives
- Landowner agreements

Regardless of the tools a local government chooses to use to implement the Regulation, there are three basic things that the applicable regulatory process needs to provide:

1. Definitions of streams and riparian areas that is consistent with the Regulation.
2. A means of triggering a regulatory action if a development activity is proposed to occur in a riparian assessment area.
3. A means of requiring an assessment report by a Qualified Environmental Professional (QEP).

Essentially, if a development occurs near a riparian area, the local government cannot approve it until the developer hires a QEP to undertake an assessment of the area. The developer must have an assessment report completed to support their application to the local government for development approval if they are proposing development within 30 m of the high water mark of a or top of a ravine back of a stream. This is referred to as the Riparian Assessment Area.

Once an assessment of the RAA has been completed by a QEP, the area is then referred to as the Streamside Protection and Enhancement Area (SPEA). The SPEA could result in a change in the riparian area or "setback" (i.e. the area where development will not be permitted). The QEP specifies the appropriate SPEA width following the applicable methodology and outlines measures required to maintain the integrity of the SPEA.

The QEP assessment report must include:

1. Certification that the QEP is qualified to conduct the assessment,
2. Certification by the QEP that the assessment methodologies outlined in the regulation were followed, and
3. A professional opinion is provided that no harmful alteration, disruption or destruction of fish habitat will occur as a result of the development.

Instead of having a QEP complete the assessment report, the developer can apply directly to Department of Fisheries and Oceans (DFO) for authorization or a letter of advice on the project.

Recommendation:
The District should ensure that the RAR process is applied in all stormwater management activities where applicable.

Note that in a February 6, 2006 memo to Mayor & Council from the Director of Development Services, a recommendation was made to amend the Zoning Bylaw to include Okanagan Lake to the list of watercourses requiring minimum setbacks. This indicates that Council and Staff are aware of, and support the RAR process.

2.1.3 Groundwater

Issue:
What measures should the District of Summerland take to ensure that:

a) groundwater does not adversely impact proposed development, and that.

b) conversely, proposed development does not adversely impact groundwater conditions?

Discussion:
Although the *Master Drainage Plan* is primarily focused on managing surface runoff, groundwater within the study area can and does have a significant impact upon development. Some sites within the study area have been identified as having a high groundwater table, and are characterized by surface discharges (springs or marshy areas). Significant works are often required to collect and divert such groundwater to appropriate drainage systems. Since groundwater tends to flow for longer durations than surface runoff, sometimes even perennially, there can often be significant downstream impacts when it is diverted into an open-channel drainage system that is normally dry.

Development can, in turn, also have a significant impact on the groundwater regime. It can alter the natural subsurface flow direction so that areas which depend upon groundwater are deprived of it. Alternatively, other areas which previously had no groundwater problems can sometime become inundated. This is often due to the installation of footing drains which discharge to a collection system and ultimately to ditches, detention ponds, or in-ground disposal systems – causing the groundwater level in these locations to rise.

Recommendation:
If a proposed development is located, even partially, within an area with a known or suspected high groundwater table, a site-specific groundwater investigation should be required as part of the development application review process. This investigation should identify groundwater conditions and recommend specific measures to mitigate potential problems.

2.1.4 Groundwater Recharge

Issue:

Due to increased awareness of the negative impacts to the environment of conventional stormwater management, the province has moved toward guidelines that encourage low impact stormwater management, which includes on-site disposal of runoff through infiltration. In keeping with this direction, should the District of Summerland encourage (or even require) the use of in-ground stormwater disposal systems?

Discussion:

Currently, the District Subdivision and Development Servicing Bylaw requires developers to install curb, gutter, and storm sewers for most residential and commercial developments. While it does briefly refer to "surface infiltration" and "sub-surface disposal", the concept of low impact stormwater management as promoted by the province is not emphasized. These requirements have been adopted for several reasons:

- The OCP recommends "full urban services" for these types of developments.
- Storm sewer systems were recommended in previous studies as part of the solution to groundwater problems in select areas.
- Historically, there have been maintenance problems with drywell systems.

There are also several reasons why historical problems occurred with drywells:

- Some were installed in soils that were not suited for in-ground disposal systems.
- Others were installed on hillsides and became unstable when saturated.
- Once installed, there were often no preventative measures taken during the construction period to keep sediments out of the drywells. Therefore, some units were clogged even before the subdivision was completed.

Based on the soils mapping presented in each basin plan in **Section 5**, some portions of the study area are more suitable for in-ground stormwater disposal than others. These maps provide a general guide, and should be used to flag a proposed development for further investigation for in-ground disposal system suitability.

Recommendation:

Where conditions appear favourable to implement in-ground stormwater disposal systems, a site-specific hydro-geological investigation must be completed by a Professional Hydro-geologist as part of a development's Stormwater Management Plan. If suitability is confirmed, then an in-ground disposal system should be designed and constructed based on the recommendations of the hydro-geological report. The report should address projected life span and maintenance costs of the proposed system.

2.1.5 Slope Stability

Issue:

What steps should be taken to ensure that concentrated runoff, infiltrated into the ground, does not adversely impact slope stability?

Discussion:

Under natural, undeveloped conditions, there is a relatively stable equilibrium between groundwater flow and slope stability. Once development activity takes place, however, this equilibrium is altered. Rainfall that used to fall and infiltrate more or less uniformly over an entire area, is now concentrated into ditches, or into a minor drainage system that either discharges runoff to a channel, or infiltrates it into the ground. Under these circumstances, groundwater can mound, and on a moderate to steep slope, can potentially cause instability. Since some of the study area contains relatively steep slopes, this issue must be addressed.

Although ditches along hillside roads pose potential problems if perennial streams are diverted into them, in-ground stormwater disposal systems are of particular concern. As presented in **Section 2.1.4**, infiltration systems are becoming more acceptable within the province to minimize impacts to stormwater quality and to reduce impacts to natural streams. If these systems are to be considered, then it is essential that an adequate, detailed investigation be completed to ensure slopes remain stable.

Recommendation:

Whenever in-ground stormwater disposal systems are considered for use within a development, or whenever there is potential for significant amounts of surface water to be concentrated prior to infiltration, the issue of groundwater-induced slope instability should be adequately addressed as part of the development application review process.

2.1.6 Lot Grading Plans

Issue:

How detailed should the required lot grading plan be, and how strict should the District be in implementing it?

Discussion:

The subdivision bylaw (section 2.02) requires that a developer prepare a lot grading plan as part of the design submission. Little else is said, however, about what this plan is to include and how it is to be used during the actual development and construction phases. The intent of the plan is to ensure that runoff from lot-to-lot is managed in a controlled manner so that properties downstream of a higher property is not negatively impacted by potential runoff from that property.

For example, if provisions have not been made to accommodate runoff from a higher, adjacent parcel, roof leader discharges could potentially flow into the lower house, or cut a path through an embankment or landscaping feature, or deposit materials onto the lower parcel. While the concept of a lot grading plan is good, it must be detailed enough to provide adequate drainage, and must be backed by a process that ensures implementation and compliance.

In many municipalities, implementation of the lot grading plan becomes a requirement of the building permit. In this case, the home owner or building contractor must demonstrate (usually through a topographic survey) that:

- The minimum building elevation has not been violated
- The finished landscaping conforms to the specified plan contours, and that
- Appropriate erosion prevention measures have been implemented

Recommendation:
The District should revise the subdivision bylaw to include more specific requirements for a detailed lot grading plan. It should also revise the building permit process to include compliance with the lot grading plan as a requirement of the building permit.

2.1.7 Deficiency Mitigation – Proposed Projects

Issue:
Should the District of Summerland be reactive or proactive with respect to correcting existing deficiencies, especially those associated with emergency drainage routes?

Discussion:
The *Master Drainage Plan* has identified a number of existing and potential deficiencies. These have been prioritized as per the criteria outlined in **Section 3.6**. Based on the definition of the priorities, it is obvious that the District should take a proactive approach in addressing Priority 1 deficiencies. The question is how proactive should the District be toward correcting Priority 2 and 3 deficiencies?

To be proactive means that the District initiate the implementation process necessary to complete the recommended works before design runoff conditions occur. To be reactive means that nothing is done until design conditions occur and affected property owners complain, or even worse, pursue legal action.

Deficiencies categorized as Priority 2 become essentially Priority 1 when upstream development occurs. These types of deficiencies should be addressed at that time.

Priority 3 deficiencies, by definition, are unlikely to cause any significant damage. The term "significant damage" however, is subjective – it may seem significant to those directly impacted, but insignificant compared to the cost of correcting the deficiency. From the District's perspective, this category of deficiencies could be corrected proactively if implemented as part of another capital works project (road upgrade or sanitary sewer installation, for example). However, the District could also choose to postpone any improvements until it is proven (an overflow event occurs) that mitigative works are required.

Recommendation:

The District should develop an immediate plan to proactively address Priority 1 deficiencies. Priority 2 deficiencies should be proactively addressed when and if they are impacted by proposed development. Priority 3 deficiencies could be proactively addressed as part of other capital works projects, or reactively addressed if and when conditions require action.

2.1.8 Deficiency Mitigation - Unplanned Emergency Drainage Routes

Issue:

What should the District do to address the potential problems associated with existing emergency drainage routes which have either not been planned for, or have been neglected?

Discussion:

An emergency drainage route (EDR) is the path runoff from extreme events will flow when it cannot enter or stay within the formal convenience (minor) system. Unplanned EDRs simply mean that the routes are not recognized as such by the owners of the properties through which they pass. Because of this, there is risk of property damage should runoff flow through these routes.

In most cases, these routes do not comprise the primary drainage routes for the basin. Instead, they service small areas that drain to low points which have no planned overflow route. **Figure C-1** in **Appendix C** illustrates a typical situation where runoff would flow through a residential lot should the minor system catch basin become either clogged or have its capacity exceeded. In most cases, the unplanned emergency drainage route usually starts at either a low point in a road, or at the end of a cul-de-sac which slopes away from the main road.

It is beyond the scope of the *Master Drainage Plan* to individually address the issues associated with each of these sites within the study area. This would require:

- drainage area delineation
- peak flow and runoff volume estimation
- mitigative option development, and
- cost estimation

Sites which appear to carry higher risk of damage have been included in the Proposed Works part of each section. This does not mean that damage at the sites not specifically addressed would be insignificant. Indeed, the affected property owner would consider any damage to be very significant! It does mean, however, that the risk of high flows and extensive damage is probably low.

It may be economically unfeasible for the District to implement mitigative measures at each of the identified unplanned emergency route sites. In most cases, the route contains extensive landscaping, and/or major buildings. This precludes open channels and would require a piped solution. The cost of installing a piped storm sewer and restoring the landscaping at each site could be extensive.

Conversely, some sites may offer the opportunity to implement simple measures that could reduce the potential for property damage. These measures should be identified and implemented where feasible.

Recommendation:
Develop a policy which defines the conditions under which mitigative measures should be implemented. Also develop and implement a systematic plan to address the following for each identified unplanned emergency drainage route:

- evaluate risk in terms of design flow, frequency, and potential damage
- identify mitigative options
- assign priorities
- include highest-priority works in the annual maintenance budget
- develop a method of collecting funds for this specific maintenance issue

2.1.9 Allowable Runoff from Developments

Issue:
What type of policy should the District adopt in order to limit the peak runoff rates discharged from future developments?

Discussion:
Currently, the District of Summerland requires developers to construct on-site works to limit peak stormwater discharges from their developments to "the pre-development 10 year peak flow rate". While this is a good policy, its implementation has had some challenges.

As demonstrated by the July, 2007 rainfall event discussed in **Appendix F**, and from other anecdotal evidence, the amount of runoff which is generated on natural, undeveloped areas is often zero. Observations also suggest that even if portions of a catchment generate surface runoff (from bedrock or rural roads, for example), these flows quickly spread over pervious areas and infiltrate before reaching major drainage routes. This anecdotal evidence contradicts the pre-development flows calculated by Developers' Engineers using currently approved methods.

Typically, the Rational Method is used to calculate peak flow rates. One of the parameters used by the Rational Method is the runoff coefficient. Currently, the Summerland *Subdivision and Development Servicing Bylaw* does not specify runoff coefficient values to be used in these calculations. Typical values used, however, range between 0.10 to 0.15. This means that 10-15% of the rain that falls ends-up as surface runoff. It also means that the calculated pre-development flow rates are significantly higher than what might actually be observed in the field.

The problem with this approach is that both natural and constructed drainage systems, which prior to the subject development received no runoff from the subject catchment, now is subject to discharged runoff every time it rains. In natural ravines or streams, this repetitive exposure to higher and more frequent flow rates often results in channel erosion and downstream sediment deposition. Where the downstream system is constructed, there is potential for the hydraulic capacity to be exceeded, causing flooding.
So, while the Development incorporates on-site works to limit runoff discharges to a theoretically-correct pre-development peak flow rate, in actuality, downstream systems can be inundated by flows which are too high.

One option is to specify significantly lower runoff coefficients for undeveloped land. Those currently recommended in most bylaws are for design purposes. This means that the values ensure the design flow rates include a factor of safety so that the proposed works are not undersized. A separate set of runoff coefficients specified to establish pre-development runoff could be created to ensure that the pre-development flows are sufficiently low. This, however, will not address situations where predevelopment conditions includes some pervious areas, since the Rational Method does not take into account the potential for infiltration once runoff from an impervious area flows onto a pervious area.

Another option is to specify a unit runoff rate which takes these conditions into account. This would require analysis to ensure that the specified unit rate reasonably reflects pre-development conditions. Application of this method is simple (area x unit runoff rate = allowable discharge rate), which makes reviewing development applications easier for Staff. On the other hand, this simplicity removes the opportunity to make allowances for atypical conditions.

Recommendation:
Update the "post = pre" runoff policy so that calculated allowable discharge rates for future developments are more representative of actual pre-development conditions. Use either the Rational Method based on a set of runoff coefficients specifically selected for pre-development considerations, or a unit runoff rate based on analysis of existing conditions.

2.1.10 Drainage Plan Implementation

Issue:
How should the Master Drainage Plan be implemented?

Discussion:
It is one thing to prepare a plan, but quite another to implement it effectively. The District of Summerland must understand the issues, "buy into" the recommendations, and commit to taking action to implement them.

The *Master Drainage Plan* provides the framework within which stormwater management facilities are to be designed and constructed. There are several types of events that would trigger action with respect to constructing new or upgraded stormwater management facilities. These are as follows:

- Development applications,
- Routine maintenance by the District,
- Planned road or utility upgrades, and
- Mitigation of persistent or significant system failures.

In each case, the *Master Drainage Plan* should be consulted for background and design information, and to determine if there are any identified projects that would impact or be impacted by the triggering event.

Recommendation:
District Staff should develop the habit of consulting the *Master Drainage Plan* whenever a triggering event (as defined above) occurs. They should also use the *Master Drainage Plan* to define projects for capital expenditure and annual maintenance plans.

The *Master Drainage Plan* should be considered as a current reference document. It is formatted to facilitate continual updating, and should be updated whenever new information develops. Potential updates could be initiated by any of the following:

- discovery of existing drainage infrastructure which is not shown in the MDP - place a sketch showing the location, extent, and available details of the item or items in the appropriate section of Volume 2)

- new or revised development concepts – insert a sketch showing the location and description of any new or revised development concepts next to the land use figure in the appropriate section of Volume 2 – this will serve as a reminder when considering development applications

- completed MDP project – insert a copy of the composite plan or as-constructed drawings adjacent to the appropriate project sheet; mark "Completed" on the project sheet and perhaps even on **Table 6.1**

2.2 Guiding Principles

This section outlines the key principles upon which the *Master Drainage Plan* has been developed. Some of these principles are reflected in current District of Summerland policies. Others are stated as objectives within various District documents, but are not official policy. Still others are based on a growing awareness on the part of District Staff, Council, and the Public of certain issues, and reflect a collective desire to address these issues in a satisfactory manner. Guiding Principles differ from design or analysis criteria in that they provide the context for what is to be analyzed or designed rather than how it should be accomplished.

The following set of Guiding Principles is not exhaustive. Nor is it unalterable. It is hoped, however, that it adequately and accurately reflects the District's current storm water management philosophy.

2.2.1 Dual Drainage Systems

Issue:

Most developments are constructed with a planned convenience drainage system. Recent system failures in the Okanagan, however, underscore the need to ensure that an emergency drainage system also exists.

Discussion:

There are two key drainage systems that must be considered in the stormwater management discussion. The first is the convenience system and the second is the emergency system. Each system plays a distinct role and differs significantly from each other as described below:

Convenience System - The convenience system (also called the "minor" system) is designed to accommodate runoff from frequent rainfall and snowmelt events. It is constructed to minimize inconveniences to both pedestrian and vehicular traffic due to surface ponding and flooding. System components usually include roof gutters, rainwater leaders, service connections, swales, street gutters, catch basins, and storm sewers. It may also include detention ponds and various facilities to enhance stormwater quality prior to discharge to receiving waters.

Emergency System - The emergency system (also called the "major" system) is intended to lessen the risk of property damage and/or loss of life due to flooding caused by less frequent rainfall events. It usually consists of natural streams, gullies, man-made streets, swales, channels, culverts, and in some instances, even large storm sewers. This system operates only when the convenience system fails, usually under extremely high runoff conditions. Since convenience systems usually fail infrequently, the emergency system must be able to function reliably after years of disuse, often without warning, and usually without intervention by District Staff.

For example, wherever a low point occurs at the entrance to a convenience system, an emergency overflow route must be identified and protected. Under these conditions, when the inlet's capacity is exceeded under high runoff conditions, or when the inlet becomes blocked by debris, there is a planned route for the excess runoff to safely reach the receiving channel or water. If there is no entrance to a convenience system at such a low point, then the existing or proposed emergency drainage route becomes the convenience system by default.

In the past, it has often been assumed that because a convenience system has been constructed, natural drainage routes downstream of the inlets can be filled-in or constructed on. This approach puts property, and sometimes human life, in jeopardy.

Guiding Principle:
The District of Summerland uses dual drainage systems – the minor system for convenience purposes, and an emergency system for protection when the minor system fails. In the *Master Drainage Plan*, primary emergency drainage routes and associated structures are identified. Future development should respect these routes and incorporate them into their plans. Where the primary emergency drainage system within a developed area proves to be inadequate, the *Master Drainage Plan* identifies and recommends appropriate corrective actions.

"It must be remembered that the major system will exist in a community whether or not it has been planned or designed and whether or not development has been wisely situated with respect to it."
URBAN DESIGN GUIDELINES, PROVINCE OF ONTARIO

2.2.2 Piped Emergency Drainage Routes

Issue:
Under what circumstances should piped systems be used as emergency drainage routes?

Discussion:
When development is allowed to occur upstream of private property, prior considerations must be given to the potential for downstream damage should stormwater management facilities within the new development fail. (This also holds true for lots within sub-divisions that are downstream of low points in roads.) Therefore, it is extremely important for the emergency drainage system to function properly while providing maximum, cost- effective protection. Excessive runoff must be safely conveyed from the development to an appropriate receiving water or downstream major drainage route.

In most situations, surface emergency drainage routes provide the most protection because they usually are designed with some freeboard. This provides significantly increased capacity as flow depths rise. Open channels inherently provide a greater factor-of-safety than piped systems.

There are, however, situations where use of an open channel may not be appropriate. Two of the most common are:

- routes over extremely steep slopes, and
- routes through developed areas with insufficient room for an open channel

Some of the challenges of using a piped emergency system are as follows:

- Inlets to piped systems are often subject to clogging by sediment and / or debris. This is especially true under extreme runoff conditions.
- Once a piped system is installed, new development often occurs within the natural drainage route downstream of the inlet that would not have occurred otherwise. This can result in potentially greater downstream damage if the inlet fails than if the piped system had not been installed in the first place.

Guiding Principle:
In the *Master Drainage Plan*, piped emergency drainage routes are proposed only when surface drainage routes are not feasible.

Note:
When used, the Design Engineer must ensure that:

- inlet structures are appropriately sized and designed to minimize clogging
- development downstream of inlets is planned to minimize potential damage should the inlets fail, and that

When surface routes are used, it is essential that:

- an easement or right-of-way is obtained in favour of the District
- appropriate works are constructed to ensure adequate capacity, and that
- potential erosion is adequately addressed

In all cases, an on-going inspection and maintenance plan for emergency drainage routes should be developed and implemented.

2.2.3 Multiple Community Values

Issue:
While the primary objective of the *Master Drainage Plan* is to ensure that adequate drainage facilities exist to protect the public (people, property, and infrastructure) from flooding, other values must be considered.

Discussion:
Historically, municipalities have constructed drainage works (ditches, culverts, storm sewers, curbs & gutters) to ensure that surface runoff generated by rainfall or snowmelt is effectively and efficiently drained to a receiving water. The objectives were to protect properties from flooding, eliminate the inconvenience of puddles, and increase the life roads. As outlined in **Section 2.2.4**, the effectiveness

and efficiency of these drainage systems have unintended impacts to the environment. Increased flow rates and volumes often cause degradation of streams and lakes due to:

- stream bed and bank erosion,
- deposition of sediments, and
- introduction of pollutants.

In addition, the rapid transport of runoff to receiving waters reduces the amount of water entering the soil. This in turn reduces water available for plant growth and for maintaining stream flow during drier periods.

Provincial and local governments are recognizing that natural resources such as streams, fish, riparian areas, lakes and lake shores are valuable and worth protecting. In addition to the inherent value of these resources, the community also values their aesthetic and recreational properties.

Guiding Principle:
In addition to protecting life and property, stormwater management should also ensure that natural water resources are protected from erosion, sedimentation, pollutants, and source depletion.

2.2.4 Low Impact Development Methods

Issue:
How can the District of Summerland adopt a more sustainable approach to stormwater management, which gives greater consideration to environmental concerns, while still providing adequate protection of life and property?

Discussion:
Conventional storm sewer systems have been, and still are being used to collect and transport rainfall runoff from developed areas to receiving waters. While this usually serves the developed areas well, the downstream impacts are becoming less acceptable to society. These impacts include, but are not limited to:

- reduction in base stream flows due to reduced groundwater recharge
- stream channel erosion due to higher and more frequent peak flow rates
- sediment deposition
- destruction of fish habitat
- transportation of pollutants to the receiving waters

A significant amount of research and practical experimentation has been conducted during the last two decades to develop more low impact approaches to stormwater management. In many cases, solutions are dependent upon more than just new drainage technologies and products – they often also require innovative changes to land use, road standards, and landscaping.

Conventional drainage systems have their place, but experience indicates that other solutions are available, and may even be preferred. In general, low impact stormwater management, which can only be implemented as part of an overall low impact development approach, involves the following elements:

- infiltration to ground (to maintain groundwater recharge)
- temporary storage through physical structures and/or amended soils (which also enhance groundwater recharge)
- reduced impervious area (narrower roads, different surface treatments)
- breaking the direct connection between an impervious surface and the drainage system

The District's *Official Community Plan* recognizes the community's desire to maintain and protect environmentally significant areas. However, implementation of such strategies will take innovation, courage, and a willingness to make adjustments as necessary. Challenges include, but are not be limited to:

- revising current planning and engineering documents and bylaws to reflect the LID concepts
- providing developers with tools and guidelines to assist them with their plans and designs
- revising building permit requirements and inspection processes to ensure compliance
- establishing monitoring protocols responsibilities to enhance understanding and to provide increased confidence in the LID concept
- modifying inspection and maintenance procedures to ensure longevity

Guiding Principle:
Low impact stormwater management strategies should be used wherever feasible. Conventional drainage systems should be allowed only when low impact methods prove unfeasible. However, if conventional systems are to be implemented, appropriate measures should be taken to mitigate potential negative downstream impacts.

2.2.5 Irrigation Impacts

Issue:
What should the District do to ensure that irrigation water applied to landscaping in new developments or previously-dry agricultural land, does not have a negative impact to existing downstream development?

Discussion:
Development often occurs on land which has previously been not irrigated. Since a significant portion of new development consists of landscaping that requires irrigation, an additional, significant amount of

water can be introduced to a previously "dry" area. This is also true for agricultural land which has not yet been irrigated. Analysis indicates that for the Okanagan Valley, the additional irrigation can equal the annual precipitation volume!

In some instances, the extra water infiltrates into shallow or perched groundwater tables, raising their levels and causing problems within existing, downstream developments. Problems include, but are not limited to:

- Surface discharge on slopes and cut banks
- Soil sloughing
- Asphalt / concrete paving cracks and/or upheaval
- Building settlement
- Leakage into basements

Guiding Principle:
The impacts of introducing irrigation water to dry land should be identified. Where there is a high potential for this to negatively impact downstream properties, mitigative measures should be incorporated into the development design. In the case of dry agricultural land, an irrigation management plan should be developed to minimize potential negative impacts.

Note:
While engineered solutions are one possibility for development, another option is to require xeriscape landscaping. For all developments on previously dry land, the District should require a hydro-geotechnical report which identifies the potential for, and addresses the impacts of problems associated with the introduction of irrigation water.

3.0 DESIGN CRITERIA AND ASSUMPTIONS

This section presents the criteria and assumptions adopted to conduct analyses, prepare conceptual designs, and estimate capital costs for the *Master Drainage Plan*. It also contains the standards against which existing and proposed stormwater management facilities have been evaluated to determine adequacy and feasibility.

Note that in some cases, different analysis criteria were used for the Phase 1 and Phase 2 portions of this study. This is largely due to the fact that XPSWMM was used to model the hydrology and hydraulic conditions in Phase 1, while GSSHA was used to model the hydrology in Phase 2. These items are discussed in more detail within the following sections.

3.1 Integration with Other District Documents

To various degrees, stormwater management within the study area is addressed in two policy documents;

- the *Subdivision And Development Servicing Bylaw No. 99-004* (*subdivision bylaw),* and
- the *Official Community Plan (OCP).*

The *Master Drainage Plan* provides the framework within which the general policies outlined in the OCP can be implemented. The subdivision bylaw, however, sets many of the design and analysis criteria used within the *Master Drainage Plan*. Since all of these documents are periodically updated, it is essential that discrepancies between them be identified and thoroughly addressed to ensure an increasingly cohesive and integrated set of policies is developed. Although no major discrepancies have been identified, District Staff should note issues that arise during the rezoning and land development processes. These can then be adequately addressed.

3.2 Peak Flow Estimation Methods

In order to identify existing and potential capacity deficiencies, it is necessary to estimate peak flow rates under key conditions. For the purposes of the *Master Drainage Plan*, computer models were created to facilitate this process. However, additional methods were used to provide base flows and snowmelt peak flows from large natural catchments. In some cases, these additional methods were used to confirm model results. Spreadsheets were used to evaluate the hydraulic capacity of existing pipe and culvert infrastructure for Phase 2.

Computer Models

The peak flow estimation analyses conducted for the *Master Drainage Plan* are for general planning purposes. Schedule "C.8", Section 2.02 of the subdivision bylaw specifies that the OTTHYMO or MIDUSS computer models are to be used for this purpose. Since the bylaw was written, significant advances in modeling software have occurred, and other packages offer similar analytical capabilities while providing enhanced user interfaces.

Phase 1 – InfoSWMM

For the Phase 1 portion of the *Master Drainage Plan*, MWHSoft's InfoSWMM - which is based on the US EPA's SWMM engine – was selected. SWMM is one of the most widely-used modeling engines in North America, and therefore provides a high level of reliability. The InfoSWMM interface was chosen because it has excellent GIS-based tools that take advantage of the data available in the District's GIS. For example:

- Aerial photographs can be combined with contours and hill-shading to better define catchment boundaries.
- Modeled conduits and junctions can be shown in context with any of the GIS data.
- Catchment data (area, slope, soil type, etc…) can be developed using GIS tools, then be imported to the model through a field-mapping exercise.
- Model elements such as conduits and junctions can be displayed in different ways based on characteristics or model results.

Note that although the subdivision bylaw forbids the use of the "SCS method", the SCS soil classification terminology was used to categorize the infiltration characteristics of the study area soils. This was done because there is no available source of infiltration parameter data for each of the mapped surficial soils. More discussion about how the soils infiltration parameters were developed is given in **Section 3.3.7**.

Phase 2 – GSSHA

For the Phase 2 portion of the *Master Drainage Plan*, the preferred modeling software was changed to GSSHA (Gridded Surface Subsurface Hydrologic Analysis) by the U.S. Army Corp of Engineers. The reasons for this mid-stream switch are as follows:

- Most of the basins within Phase 2 have very little urban development and corresponding drainage infrastructure. Therefore, runoff generated on impervious (hard) surfaces tends to flow onto areas where it can infiltrate to the ground. Even if flows enter natural drainage courses, they tend to infiltrate before traveling too far along these routes.
- While InfoSWMM can model these processes to some extent, it can do so only by using very broad assumptions which are applied to each sub-catchment. This approach is called the "lumped parameter method". In 2005, when the Phase 1 study was initiated, there were no viable alternatives to this approach.

- Within the last few years, both computer hardware and modeling software have been developed to the point where sub-catchments can be divided into small cells – each of which can be described by its own hydrologic characteristics. This "distributed modeling" approach is better suited for simulating the relationships between rainfall, surface ground conditions, and sub-surface soil characteristics.
- Since the Phase 2 basins are primarily natural or rural, the ability to better model what happens to rainfall when it lands, forms surface runoff, and flows over pervious surfaces, was key in the decision to use GSSHA.

Note that while GSSHA provides significantly improved modeling capabilities with respect to a basin's hydrology, it currently has very limited hydraulic analysis capabilities. For the purposes of this *Master Drainage Plan*, however, this was not deemed a problem for the reasons outlined as follows:

- The Phase 2 basins contain very little drainage infrastructure, and for what does exist,
- Insufficient data (invert elevations, lengths, slope, etc…) are available to accurately analyze the infrastructures' hydraulic capacity.
- Very few of the existing storm sewers are subject to backwater effects from the lake or other water body. In cases where this might occur, much more detailed information (which was not available at the time of this study) is required to conduct such analyses.

Therefore, Manning's Formula was used in a spreadsheet to conduct rudimentary hydraulic capacity analysis for the identified links (stream reaches, constructed open channels, and storm sewers). An inlet capacity nomograph was used for estimating circular culvert capacity as outlined in **Section 3.4.3**. Peak flows were extracted at select locations and imported into this spreadsheet to determine potential hydraulic capacity deficiencies.

Regional Analysis

For the larger watersheds within the study area which maintain perennial streams, peak flows usually occur during spring freshet. This is a snowmelt-induced phenomenon, and therefore requires a more suitable peak flow estimation method than that offered by the computer models. The Ministry of Environment has published a set of Regional Analysis data which allows the user to estimate design peak flows for any large basin within the subject hydrological region. Although the models were used to estimate peak flows under design conditions for the basins within the lower reaches of the large watersheds, Regional Analysis was also used to estimate base and freshet flows. This ensures that all of the critical runoff conditions have been adequately evaluated.

Rational Method

In a very few instances, and for small catchment areas, the Rational Method was also used to estimate peak runoff from rainfall events. This was done for specific projects late in the *Master Drainage Plan* development process where model revisions would have taken more effort than justified. Results were compared with InfoSWMM values generated for adjacent or similar catchments to ensure continuity.

The Rational Method is expressed as:

$$Qpeak = k\,C\,i\,A$$

Where:

Qpeak = peak flow [m^3/s]
K = 0.0028
C = runoff coefficient (see **Table A-4** in **Appendix A**)
i = rainfall intensity [mm/hr]
A = catchment area [ha]

3.3 Hydrological Criteria

The criteria presented in this section govern the process of converting rainfall to surface runoff. Each element has an impact either on the characteristic of the rainfall, or on what happens to the rain when it reaches the ground.

3.3.1 Return Periods

The convenience and emergency stormwater management systems are each designed to provide different levels of service. The convenience system minimizes the nuisance associated with frequent rainfall events while the emergency system protects life and property when the convenience system fails. As outlined in Schedule "C.8", Section 2.05 of the subdivision bylaw:

- the convenience (minor) system must be designed to convey flows with return periods of up to 10 years, and
- the emergency (major) system must be capable of accommodating runoff from events with return periods of at least 100 years.

Note that certain structures must be designed to accommodate peak flows with a 200 year return period. These are identified where applicable. Also note that for Phase 1, 25 year return period rainfall events were used to "calibrate" the model. This process is described in more detail in **Section 4.1**.

3.3.2 IDF Curves

Atmospheric Environment Service of Canada (AES) has prepared a set of IDF curves for Summerland's meteorological station. These curves are included in **Appendix A.**

Since many of the calculations for this study are completed using computer-based tools, the AES plotting equation has been used to calculate the required intensities (rather than manually interpreting them from the actual curve). The equation is:

$$I = a\ t^{b}$$

Where: I = rainfall rate in mm/hour;
t = time in hours; and

Return Period (yrs)	2	5	10	25	50	100
Coefficient a	7.81	10.44	12.12	14.68	16.27	17.72
Exponent b	-0.668	-0695	-0.706	-0.714	-0.718	-0.722

3.3.3 Storm Durations

When sizing stormwater management works, the designer must consider both peak flow and runoff volume. Usually, one or the other becomes the governing factor. For example, the governing criteria for a culvert may be peak flow if there is no available headwater storage. On the other hand, runoff volume may be the governing factor when sizing a detention pond.

Drainage basin size and characteristics also play an important role in determining the critical design conditions for any given works. For example, a small, highly urbanized drainage basin would exhibit a high peak runoff rate from a relatively short duration storm, and a low peak flow from a long duration storm. The converse would be true of a large, rural basin.

Therefore, for any given works, it is essential to determine which storm duration yields the critical design conditions. This becomes the critical design storm for that stormwater management facility. **Table A-1** in **Appendix A** summarizes the rainfall volume for various combinations of select storm durations and return periods. These become part of the input to the modeling process.

3.3.4 Rainfall Patterns

Precipitation does not normally fall at a uniform rate during a storm; the rainfall rate (intensity) varies throughout the event. For the analyses conducted for the *Master Drainage Plan*, several curves based on statistically analyzed data are used to simulate rainfall patterns for different storm durations. The Atmospheric Environment Service developed a set of curves for the BC interior which show the portion of total rain that has fallen within a given portion of a storm's total duration. Located in **Appendix A,** these curves are provided for storm durations of 6 hours or less and from 6 to 24 hours. A uniform (flat) storm pattern is assumed for durations exceeding 24 hours.

3.3.5 Land Use

One of the influencing factors on how a drainage basin responds to rainfall and snowmelt events is land use. The associated parameters are:

- percent of directly connected impervious surface (the ratio of hard-surface area which drains directly to a storm sewer system to the total catchment area)
- the amount of surface depression storage
- surface roughness coefficients (impervious and pervious areas) – used for determining how quickly surface runoff flows across the catchment to its outlet
- average sub-catchment slope

A GIS of existing and proposed land use was prepared for the District by Urban Systems as part of another initiative. Values for the above parameters were allocated to each land use type, and a spatial analysis was used to develop weighted values for each sub-catchment (Phase 1) or grid cell (Phase 2).

3.3.6 Imperviousness

Imperviousness is the ratio of total hard surface area (that which allows no infiltration) to the total catchment area. Directly connected imperviousness is the ratio of hard surface area (which drains directly to a storm sewer) to the total catchment area.

Phase 1 - InfoSWMM

The computer model used for the Phase 1 analyses in this document allows any portion of runoff from the total impervious area to be routed onto the pervious portion of the catchment. In this way, the concept of "directly connected impervious areas" can be implemented, but the ratio itself not expressed directly. The amount of total and directly connected imperviousness for each catchment was estimated from aerial photographs for existing development.

Table 3.1
Future Land Use Imperviousness

Land Use	Imperviousness	
	Total	Directly Connected
Single Family Residential	30	15
Multi Family Residential	60	25
Commercial / Industrial	80	30

Phase 2 - GSSHA

In Phase 2, each grid cell is assigned only one land use & soil combination. In this case, a 10 m x 10 m (100 m^2) grid cell was specified. This is considered small enough to represent a single surface (road, house, field, etc…). The issue of what is or is not directly connected is inherently modeled in GSSHA by a cell's proximity to a channel, which is used to simulate flow conduits.

3.3.7 Surficial Soils

The infiltration capacities of surface and subsurface soils have a significant impact on how drainage catchments respond to precipitation events. Soils with high infiltration capacity tend to capture most of the lower intensity rainfall, resulting in little or no surface runoff. The converse is true of soils with low infiltration capacity. Drainage characteristics were extracted from provincial soils mapping for the study area where available.

Phase 1

For Phase 1, the mapped soil types were assigned to one of four soil groups as defined by the United States Soil Conservation Service. The US SCS has developed a classification system for soils based on drainage characteristics. These data, combined with land use assumptions, are used to select the infiltration parameter values used by InfoSWMM for hydrological analyses. For the purposes of this document, the Horton Method was used. **Table 3.2** provides a description of each soil group's drainage characteristics, including the assumed Horton infiltration parameters.

Table 3.2

		Horton's Infiltration Parameters		
SCS Soil Classification	***Description***	**Max (mm/ hr)**	**Min (mm/ hr)**	**Decay (1/hr)**
Group A	Soils having high infiltration rates even when thoroughly wetted, consisting chiefly of sands or gravel that are deep and well to excessively drained. These soils have a high rate of water transmission.	2,500	150	2.00
Group B	Soils having moderated infiltration rates when thoroughly wetted, chiefly moderately deep to deep, moderately well to well drained, with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.	150	100	0.70
Group C	Soils having slow infiltration rates when thoroughly wetted, chiefly with a layer that impedes the downward movement of water, or of moderately fine to fine texture and a slow infiltration rate. These soils have a slow rate of water transmission.	3.5	1	0.30
Group D	Soils having very slow infiltration rates when thoroughly wetted, chiefly clay soils with high swelling potential; soils with a high permanent water table; soils with a clay pan or clay layer at or near the surface; and shallow soils over nearly impervious materials. These soils have a very slow rate of water transmission.	0.1	0.04	0.07

Phase 2

The surface infiltration characteristics used for the purposes of the GHSSA model were combined into nine different classifications, representing a combination of land use and soil type as summarized in **Table 3.3**. Surficial soils, rather than the subsurface soils, have a more significant influence upon the volume of runoff produced during a storm event. They form the initial layer of soil on the surface and are often high in organic content and porosity providing good infiltration and storage capacity during a rainfall event. Land use plays an equally, and sometimes even more significant role in the proportion of runoff produced during a storm. An impervious surface, a road for example, restricts all rainfall from infiltrating into the soil beneath - it is therefore the surface characteristics of the road alone that govern run-off.

To represent impervious surfaces in the GSSHA model, the parameters associated with USDA Textural Classifications of Sandy Loam, Clay Loam, Silt Loam, and Silty Clay were used to establish initial values. These were then adjusted based on the calibration modeling using anecdotal information from the July 19, 2007 storm event. Final values used for the analyses are summarized in **Table 3.4.**

Table 3.3
Description Of The Soil/Land Use Classifications Used In The GSSHA Model

Soil/Land Use Category	Description
Bare and Compacted	Natural areas with little vegetation or bare areas surrounding commercial or industrial buildings.
Dry and Bare	Areas that have been stripped and grubbed, exposing the subsurface soil below.
Bedrock	Rock outcrops or areas with minimal surficial soils above rock.
Dry and Natural	Natural undeveloped areas with dense vegetation
Impervious	Roads, roof tops, car parks and driveways
Irrigated Agriculture	Orchards, vineyards and other agricultural areas regularly irrigated
Irrigated Turf	Irrigated areas predominantly covered in grass such as residential lawns and pastures.
Lake or Pond	Areas permanently covered by water
Irrigated and Bare	Newly re-surfaced and planted orchards or vineyards

Table 3.4
Soil and Land Use Characteristics Used in the GSSHA Model

Parameter	Units	Bare and Compacted	Dry and Bare	Bedrock	Dry and Natural	Impervious	Irrigated Agriculture	Irrigated Turf	Lake or Pond	Irrigated and Bare
					SOIL HYDRAULIC PARAMETERS					
Soil Type		Sandy Loam	Silty Clay	Clay Loam	Sandy Loam	N/A	Sandy Loam	Sandy Loam	Sandy Loam	Silt Loam
Hydraulic Conductivity	cm/hr	2.18	0.1	0.2	2.18	0.001	2.18	2.18	2.18	0.68
Capillary Head	cm	11.01	29.22	20.88	11.01	0.1	11.01	11.01	11.01	16.68
Porosity	fraction	0.412	0.423	0.39	0.412	0.1	0.412	0.412	0.412	0.486
Porosity Index	fraction	0.378	0.15	0.242	0.378	0.01	0.378	0.378	0.378	0.234
Residual Saturation	fraction	0.041	0.056	0.075	0.041	0.01	0.041	0.041	0.041	0.015
					LAND USE PARAMETERS					
Surface Roughness		0.02	0.02	0.01	0.2	0.015	0.2	0.4	0.01	0.02
Depression Storage	mm	10	1	1	20	1	5	3.5	100	2
Soil Moisture	fraction	0.1	0.42	0.01	0.1	0.01	0.25	0.2	0.4	0.3
Evapo-Transpiration Parameters										
Albedo	fraction	0.3	0.25	0.15	0.2	0.15	0.2	0.2	0.05	0.25
Wilting Point	fraction	0.095	0.25	0.197	0.095	0.04	0.095	0.095	0.033	0.133
Vegetation Height	m	0.01	0.01	0.1	2	0.01	2	0.05	0.001	1
Vegetation Radiation Coefficient	fraction	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.01	0.2
Canopy Resistance	s/m	350	500	300	150	500	70	90	500	400

3.3.8 Time of Concentration

This parameter reflects the time it takes for a catchment to fully respond to a rainfall event. Conceptually, it is often represented as the longest time it takes a drop of water to flow on the surface from the upper reach of a catchment to its outlet.

Phase 1

There are several methods of calculating the time of concentration (Tc), but InfoSWMM (Runoff routing method) does this internally based on the following parameters:

- average catchment slope
- surface roughness coefficient
- catchment width
- rainfall intensity

The first three of the above parameter values were estimated for each catchment using the GIS. The rainfall intensity is determined during the analyses.

Phase 2

Like InfoSWMM, GSSHA also does not use time of concentration directly. However, the time it takes runoff to flow through a catchment is dependent upon:

- an inferred grid-cell slope, determined by the relative elevations of adjacent grid cells
- surface roughness coefficient
- rainfall intensity

3.3.9 Base Flows

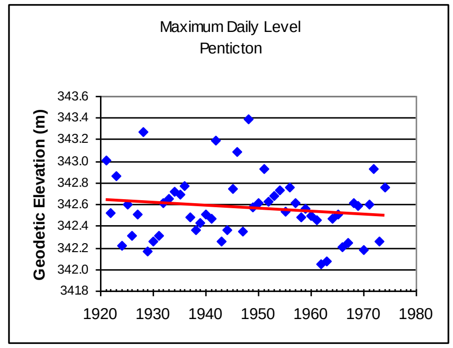
There are several streams located within the study area which exhibit perennial flows due to ground springs and/or lakes. Most fluctuate seasonally, and sometimes respond to individual rainfall events.

It is possible for a very intense rainfall event to occur during the spring freshet, when stream flows are at their highest. However, the probability that the 100 year design storm will occur during the 100 year freshet peak flow is very low (1 in 10,000). Therefore, the base flow in each of the primary streams was estimated to reflect a 10 year return period using one or more of the following methods:

- regional analysis (snowmelt event)
- field measurements and observations (for small spring-fed streams)
- anecdotal information about channel flow depth (for significant historical events)

More detail is provided about the base flow for each stream in the sections (**Section 5**) addressing each primary catchment.

3.3.10 Lake Level



Since the hydraulic capacities of the lower reaches of each stream are impacted by the backwater effect of Okanagan Lake, a lake level assumption was required for modeling purposes. The Okanagan Basin Water Board regulates the lake level to provide room for freshet runoff, which means that the level is dropped prior to freshet, and then allowed to rise to a maximum level. For the purposes of this set of analyses, the mean water level of 342.6 m was used.

3.4 Hydraulics

3.4.1 Open Channels

Hydraulic design of open channels is based on cross-sectional geometry, slope, design flow, and proposed construction materials. The Manning equation is used for hydraulic calculations under uniform flow conditions. **Table A-2** in **Appendix A** summarizes representative "n" values for open channels considered in the *Master Drainage Plan*.

Wherever possible, open channels are designed to flow under sub-critical conditions. This is often achieved by introducing check dams which create "hydraulic steps" that affect sub-critical slopes. Where this is not feasible, it is assumed that the channel will be armored to protect against erosion.

Table A-3 in **Appendix A** summarizes the maximum allowable velocities for channels constructed with various types of soils and erosion control techniques. For situations not represented by the values presented in this table, erosion protection measures must be designed based on site-specific data.

In general, all open channels should function with a minimum freeboard of 0.3 meters. If the channel is lined, then the lining freeboard may be a minimum of 0.2 meters.

3.4.2 Piped Systems

The hydraulic capacities of piped systems within the study area are calculated using the Manning equation. **Table A-2** in **Appendix A** summarizes the "n" values assumed for the various types of pipe materials used. Based on the Summerland *Subdivision and Development Servicing Bylaw*, storm sewers must be sized to ensure that the minimum velocity is 0.75 m/s when the pipe is flowing either full or half full. The maximum velocity allowed without scour-prevention considerations is 4.5 m/s.

The minimum storm sewer diameters used in this document are also taken from the subdivision bylaw, and are as follows:

- 200mm for catch basin leads (250mm for double catch basins);
- 250mm for single family residential;
- 300mm for multiple family residential, industrial, and commercial;
- 300mm (complete with a silt trap) for open ditch collection leads.

3.4.3 Culverts

Culvert capacity is dependent upon several factors:

- entrance configuration (projecting, tapered, headwall)
- controlling condition (inlet or outlet)
- geometry (diameter, length, slope)
- material (roughness coefficient)

The subdivision bylaw specifies that culverts be sized to accommodate the design peak flow at a headwater that is less than or equal to 50% of the culvert diameter. For practicality, however, existing culverts were considered deficient only when the headwater under design flow conditions exceeded the full diameter during analysis. Major system culverts are those with design flows greater than 0.01 m^3/s. All culverts crossing roads are also considered major system culverts. These assumptions have been implemented for estimating the diameter of proposed works.

Figure A-3 in **Appendix A** is a nomograph extracted from the *Handbook of Steel Drainage & Highway Construction Products* which provides the inlet capacity for circular culverts under inlet control conditions. Where there is not enough depth to install a culvert of the specified diameter, two or more culverts having the combined capacity of the larger, single unit have been specified. Regardless of calculated culvert sizes, following minimum culvert diameters have been assumed for the purposes of this study:

- 400 mm for minor system routes;
- 600 mm for major system routes

Note that all culverts must be equipped with headwalls at both ends.

3.5 Project Triggers

Some of the recommended stormwater management works may be required almost immediately to address significant existing deficiencies. However, many of the projects will be required only when a certain amount of development has occurred. Other projects may be identified as remedies for deficiencies, but because the consequences of not implementing the recommended works immediately are minor, they may be postponed until a more opportune time. These types of projects may be delayed until other utility projects are constructed, such as a new water main, sanitary sewer, or road upgrade.

Since the timing of each potential development is not known, the triggers assigned to each project in **Section 5** reflect an event or condition rather than a specific time or time period. These fall into one of the following general categories:

- development or redevelopment
- road or other utility project
- local area improvement (existing development upgrade from rural to urban road standard)
- required immediately to address current issues

3.6 Project Priorities

To help the District of Summerland develop its capital plans, each project proposed in **Section 5** has been assigned one of three priority levels. The intent is to direct available funds towards those works that pose the greatest risk to both public and private property as well as to the general public. The three priority levels are defined in the following sections.

3.6.1 Priority 1

This priority applies to proposed projects which are considered necessary to prevent significant damage to both public and private property and/or danger to the public from runoff generated under *existing* development conditions.

3.6.2 Priority 2

These proposed projects are considered necessary to prevent:

- inconvenience or annoyance from runoff generated under existing development conditions, or
- significant damage to both public and private property and/or danger to the public from runoff generated under future development conditions.

3.6.3 Priority 3

These proposed projects are considered necessary to meet identified standards, but failure to meet these standards is unlikely to cause:

- significant inconvenience from runoff generated under existing development conditions, or
- significant damage to both public and private property and/or danger to the public from runoff generated under future development conditions.

Proposed works classified as a Priority 3 may be postponed until future development occurs.

3.7 Cost Estimates

The capital cost estimates presented in this document were developed to facilitate:

- scenario comparisons
- capital plan development
- cost recovery strategy development

Although they do not include allowances for land, easement, or ROW purchases, they do include:

- 15% for engineering,
- 25% for construction contingencies

Note that these estimates are based on very limited, general information that must be refined through preliminary and detailed design processes. The District should add land-related costs where applicable to provide a complete project cost estimate.

Note that the Phase 1 costs (Prairie Valley Basin in **Section 5.1**) are based on the unit costs summarized in **Table A-5** of **Appendix A**. The costs for each project in this basin were calculated manually, and therefore, only the resultant costs summarized in **Table 6.1** are given. For the Phase 2 basins, however, standardized cost spreadsheets were created for each project and applicable land use scenario. These are included as part of each project description in **Section 5.0**, and include the assumed unit prices.

4.0 ANALYSES

This section outlines the general approach of the modeling completed in support of the *Master Drainage Plan*. Three primary sets of analyses were completed as follows:

- Existing development with existing drainage systems. This is to identify existing deficiencies and develop a baseline for evaluating impacts by future development. These conditions were also used to proof (insufficient field data are available to calibrate) each model.
- Proposed development with low impact drainage systems. This allows the District to consider the effectiveness and benefits of employing low impact stormwater management methods.
- Proposed development with conventional drainage systems. This is to determine the level of upgrades and new works necessary to service projected development if conventional stormwater management methods only were considered. It also provides a basis for comparison to potential low impact stormwater management methods.

Because different modeling software was used for the two phases, the approaches used to conduct the above analyses were slightly different for each phase. These are explained below.

Phase 1
For each of the above sets of analyses, the model was run using a series of storm durations for each of the key return periods as outlined in **Section 3.3.1**. Analysis using the 10 year storms were included because there is some minor system infrastructure within the downtown area. Results are discussed in greater detail below. The results for the basin in general, and associated sub-catchments, are discussed in **Section 5.1.**

Phase 2
GSSHA takes a considerably long time to perform each analytical run because it is processing tens-of thousands of "mini sub-catchments" – the grid cells. Therefore, in order to reduce the amount of time spent on analysis, a sample of the basins were used for a sensitivity analysis. Each of the select basins were modeled using the full spectrum of design storms, but for only the 100 year return period. (The 10 year storms were not modeled since there is very little minor system infrastructure within the Phase 2 basins.) It was found that the 1 hour duration storm generated the highest peak runoff rates, and therefore this storm was used for the rest of the Phase 2 analyses.

4.1 Existing Development with Existing Drainage Systems

The base scenario in the InfoSWMM model consists of existing development conditions and the existing drainage systems. Three separate sets of analyses were conducted using these base conditions as follows:

- 25 year rainfall (Phase 1) and the July 19, 2007 rainfall event (Phase 2) to calibrate the models
- 10 year rainfall to establish a baseline under for comparison purposes
- 100 year rainfall to establish a baseline as well as to identify potential deficiencies.

Calibration (Model Proofing)
Since reliable field data (rainfall and corresponding stream flows) do not exist for the study area, other methods must be employed to ensure that the models results reasonably reflect how each catchment and drainage system function in the field. The only readily available source of information is from those who have lived and worked in Summerland for a significant length of time. We know, for example, that:

- The current drainage systems function without any significant deficiencies;
- After a rainfall, the flow depth in streams upstream of developed areas do not rise significantly or very quickly;
- Surface runoff from undeveloped, well vegetated basins does not occur. This infers that rainfall from events with at least a 10 year return period is totally intercepted and infiltrated.

Many of the Public Works Staff have lived and worked in Summerland for many years. Based on discussions with them, we have made the following conclusions and assumptions:

- The piped systems and drywells can accommodate peak flow rates with return periods of at least 10 years.
- It takes a storm with a return period of at least 25 years to initiate runoff from an undeveloped (natural) catchment. Note that this is applicable only to catchments with low permeability soils.

With these two conclusions as performance targets, the hydrological parameter values in the model were adjusted to ensure that runoff reflected the anecdotal information. Considering that the term "calibration" infers a high level of accuracy, we prefer to use the term "proofed" rather than "calibrated".

Phase 1
For the Prairie Creek Basin, proofing was completed using the critical 25 year return period storm. (The critical storm is the one with the duration that generates the highest peak runoff rates.) The assumption is that over the last 25 years, there have been no significant system failures, and no discernable surface runoff from agricultural or natural areas. Therefore, the model parameter values for the catchments were

adjusted so that, under the critical 25 year rainfall event, surface runoff from the pervious areas was *just commencing*.

Phase 2

The proofing process for the Phase 2 models was conducted differently because on July 19, 2007, the District of Summerland experienced a very rare rainfall event which provided several sets of useful anecdotal information. While additional information about this particular event is located in **Appendix F**, the following summarizes the key issues:

- The storm plotted above the 100 year return period for almost all intensities
- its duration was approximately 11 hours – an unusually long storm
- it had an extremely high intensity peak *near the end* of its duration – after surface soils had a chance to become wetted and depressions filled
- it was extremely wide-spread, and covered the entire district
- Neither Eneas Creek nor Prairie Creek responded significantly to the event, indicating that natural and agricultural lands have a significant capacity to capture and retain rainfall
- Several flooding and erosion incidents occurred throughout the District, but all were related to:
    - Runoff generated on hard surfaces (roads, driveways) or on pervious surfaces stripped of their organic soil layer (areas being prepared for vineyards or construction)
    - Low points on roads or cul-de-sacs which have no defined downstream major drainage route

For the purpose of proofing the GSSHA models, two similar incidents where unexpected surface flows were generated, were selected. In this case:

- One incident was located on Giants Head Road – runoff was generated on land stripped for a new vineyard, and
- The other incident was located on top of the silt bluffs along Lakeshore Road – where a newly planted, but not-yet-vegetated vineyard was created in a topographic bowl.

In both cases, runoff was generated on the disturbed landscape by the storm, and followed natural topography through private lands. In the Giants Head Road case, the runoff eventually infiltrated into the ground as if flowed through a natural ravine. In the Lakeshore Road case, the runoff flowed over the silt bluffs and eventually into Okanagan Lake.

The proofing strategy was as follows:

- Develop a model of the existing conditions for the Giants Head Basin, and using the July 19, 2007 historical storm, adjust the parameter values until the generated runoff matches the flow rates estimated from anecdotal field evidence at various locations along the flow path.
- Develop a model of the Lakeshore Basin, and using the same storm and parameter values from the Giants Head Basin model, see how well the results match the flow rate estimated from anecdotal field evidence at the Lakeshore location.

The premise is that because the surface soils are similar, the same parameter values should yield similar results under the same rainfall conditions. Fortunately, this approached worked well, and the parameter values summarized in **Table 3.4** were used in each Phase 2 basin model.

Minor System Baseline – 10 Year Return Period Rainfall (Phase 1 Only)
While the focus of the Master Drainage Plan is more broad (major drainage), key elements of the minor system within the Prairie Creek Basin were modeled where necessary to connect catchments to their respective receiving streams. Therefore, the 10 year rainfall was used (after model proofing) to establish a reference for comparison when future development impacts are analyzed. Results from this analysis are found in **Section 5.1**.

Major System Baseline – 100 Year Return Period Rainfall (Phases 1 and 2)
By running the model using 100 year rainfall events, we were able to establish both a baseline for comparison as well as identify system deficiencies. Each of these deficiencies are noted in the corresponding basin drainage plan sub-sections in **Section 5**.

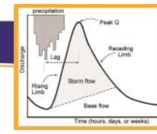
4.2 Proposed Development with Low impact Drainage Systems

The concept of low impact stormwater management is introduced in **Section 2.2**. Regardless of the method employed, the general objectives are to:

- Increase the amount of rainfall that infiltrates into the ground (for groundwater replenishment and stream health) and to
- Reduce the amount of rapid runoff and associated impacts.

Hydrological modeling uses several parameters for which values can be adjusted to simulate the function of the BMPs outlined in **Appendix B**. These are outlined as follows:

- Directly connected imperviousness – the amount of hard surface that is connected directly to a piped storm sewer system. Development methods that direct runoff onto lawns and infiltration



systems – essentially breaking the direct connection to a storm sewer – can be modeled using this parameter.

- Depression storage – the volume of surface storage that temporarily holds runoff until it is either evaporated or infiltrated. BMPs which create lot-level detention can be modeled using this parameter.
- Slope – the slope of a catchment's surface can impact how quickly overland flows reach the outlet. Flatter slopes, created by re-grading, can reduce peak runoff flows.
- Infiltration – the rate at which water moves through a soil. Adding relatively deep (0.3 – 0.5 m) of amended, well-drained soils to a development site's pervious areas can increase rainfall capture by allowing the water to move quickly into the soils rather than running off the surface. The infiltration parameters in the model can be adjusted to reflect the new soil conditions. One caveat, however, is that there is a limit to the amount of rainfall these soils can hold. This can be reflected in the model by either specifying a limit in terms of volume, or adjusting the saturated infiltration rate and decay time values accordingly.

The analyses conducted using these concepts reflect the fact that future development will increase the amount of impervious area on subject sites. However, the goal of using more low impact stormwater management methods in the model is to:

- Prevent any increase in runoff from the most frequent (and lower intensity) rainfall events;
- Minimize and delay peak runoff from the 10 year design storms, and
- Manage excess runoff generated by the 100 year design storms.

Tables within the basin sub-sections of **Section 5.0** summarize the peak flows in the systems generated using these more low impact stormwater management methods. Proposed works are presented in detail in each of the basin sub-sections in **Section 5.0.**

4.3 Proposed Development with Conventional Drainage Systems

For the purposes of this *Master Drainage Plan*, a conventional drainage system is considered to consist of:

- Curb and gutter on asphalt roads
- Catch basins connected to a piped storm sewer
- A discharge from the piped storm sewer to a receiving water (usually a stream, open ditch, or lake).

As discussed in **Section 2.2**, this type of system generates high runoff flow rates very rapidly. If a development is adjacent to a large receiving water (river or lake), the downstream impacts are minimal, and can be easily mitigated. In most cases however, runoff must be transported a significant distance before it reaches these larger receiving waters. In these situations, rapid, high peak flows can cause:

- stream bank / bed and channel erosion
- flooding
- sediment transport and deposition to undesired locations.

Conventional methods of addressing these issues include:

- detention facilities (ponds, buried systems, over-sized storm sewers)
- channel erosion protection (rip rap, geo fabrics, check-dams)
- large storm sewer installations.

For this set of analyses, conventional storm sewers were assumed for the future developments, and conventional methods of transporting the resultant peak flows (ditches and trunk storm sewers) were considered for offsite works.

Phase 1

In Phase 1, capital costs were estimated the offsite works based on the modeled peak flow rates. They also included allowances for erosion prevention measures. The results and corresponding proposed works are located in **Section 5.1**.

Phase 2

In Phase 2, the same type of analyses were also conducted. However, conventional works necessary to convey the high peak flows to an appropriate receiving water (Okanagan Lake or Trout Creek) were not identified except for a couple of locations. This reflects two key assumptions:

- Current policy requires developments to attenuate post-development peak flows to pre-development levels, and
- In many cases, the distance between the proposed development and an appropriate receiving water makes the prospect of constructing adequate drainage works unfeasible.

Therefore, conventional peak flow rates have been identified, but the proposed off-site works are more reflective of what would actually be required. It will be up to the Developers to determine the best way of attenuating post-development peak flows on-site – either through LID or conventional methods.

4.4 Proposed Unit Runoff Rates

As outlined in **Section 2.1.9**, use of a unit runoff rate to establish allowable discharge rates from future developments is recommended. This section outlines the analyses conducted to determine an appropriate unit runoff rate for areas which currently have been identified for future development.

Figure 4.4-1 shows a set of catchments which contain future development sites and which drain to a location for which flows were modeled under both existing and future LID conditions.

The analysis consisted of:

- Summing the area of the sub-catchments draining to each selected modeled flow location, and
- Dividing the modeled flow rates by their corresponding contributing catchment areas.

This analysis was conducted using modeled flow rates for both existing and LID conditions. The data are summarized in **Tables 4.4-1** and **4.4-2** respectively.

Figures 4.4-2 and **4.4-3** are plots of the land use distributions for the existing and LID conditions respectively. The catchment data are sorted left to right by the corresponding calculated unit runoff rate.

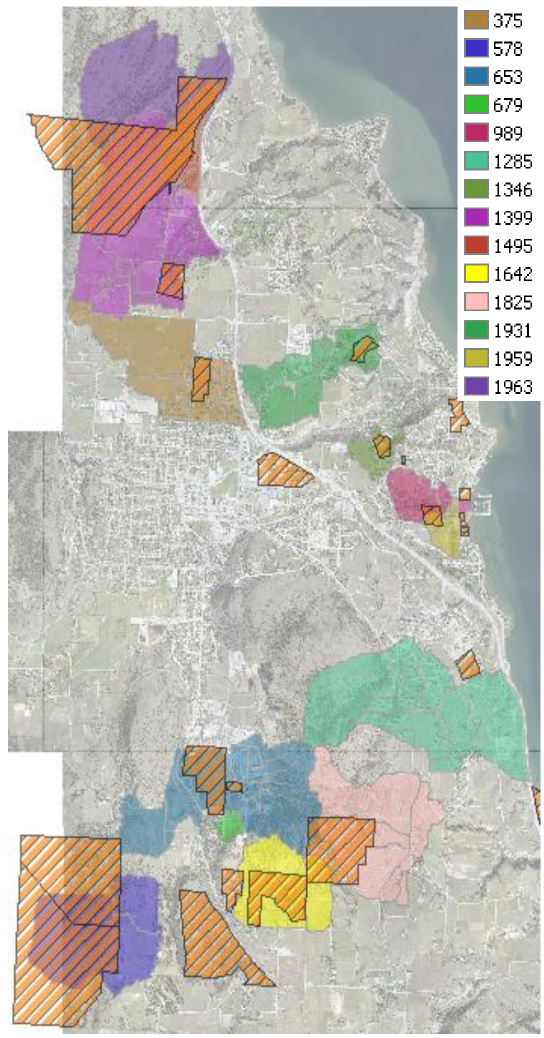


Figure 4.4-1 Catchments Used In The Unit Runoff

Table 4.4-1

Existing Land Use / Soils Conditions - Percent of Total Area										
URA ID	**Unit Runoff (Lps/ha)**	**Area (ha)**	**Bare and Compacted**	**Bedrock**	**Dry and Bare**	**Dry and Natural**	**Impervious**	**Irrigated Agriculture**	**Irrigated and Bare**	**Irrigated Turf**
375	0.07	61.6	5%			1%	17%	61%		17%
578	0.76	69.2				74%	1%	23%		2%
653	1.12	85.3	16%			34%	9%	25%		17%
679	0.81	3.7				39%	12%	6%		43%
989	1.92	15.1	17%			36%	13%	19%		16%
1285	0.28	109.2	7%			35%	9%	25%		25%
1346	0.28	9.1	21%			1%	15%	30%		33%
1399		106.3	3%			53%	4%	33%		7%
1495	0.94	19.7	5%			83%	8%	3%		3%
1642		42.7				64%	3%	23%		9%
1825	0.27	70.5		6%	1%	49%	4%	20%	10%	10%
1931		40.7	1%			9%	15%	38%		38%
1959	2.65	7.7	41%				11%	26%		23%
1963	0.02	60.0				99%	1%	0%		1%
Min	**0.00**									
Avg	**0.65**	50.1	8%	0%	0%	41%	9%	24%	1%	17%
Max	**2.65**									

Figure 4.4-2 Existing Land Use / Soils Distribution

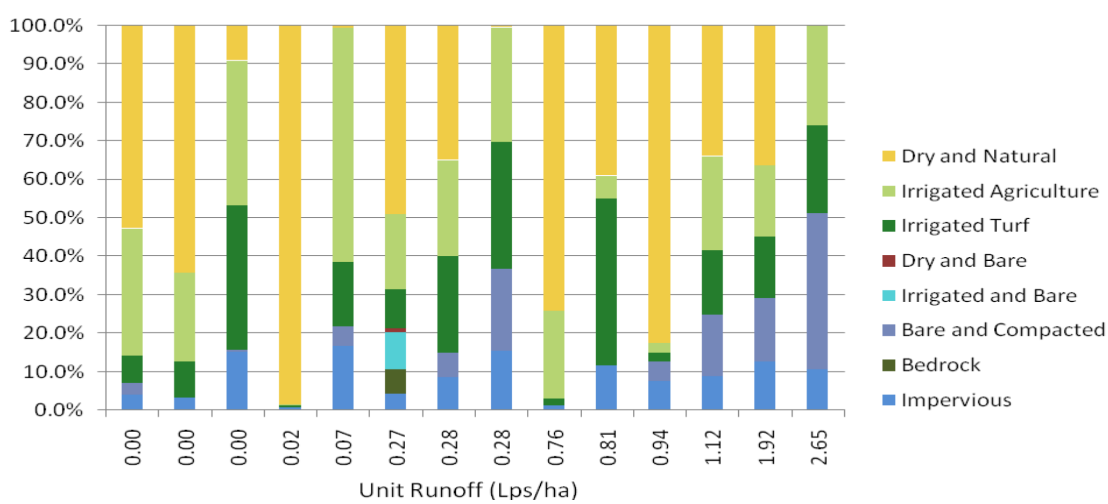
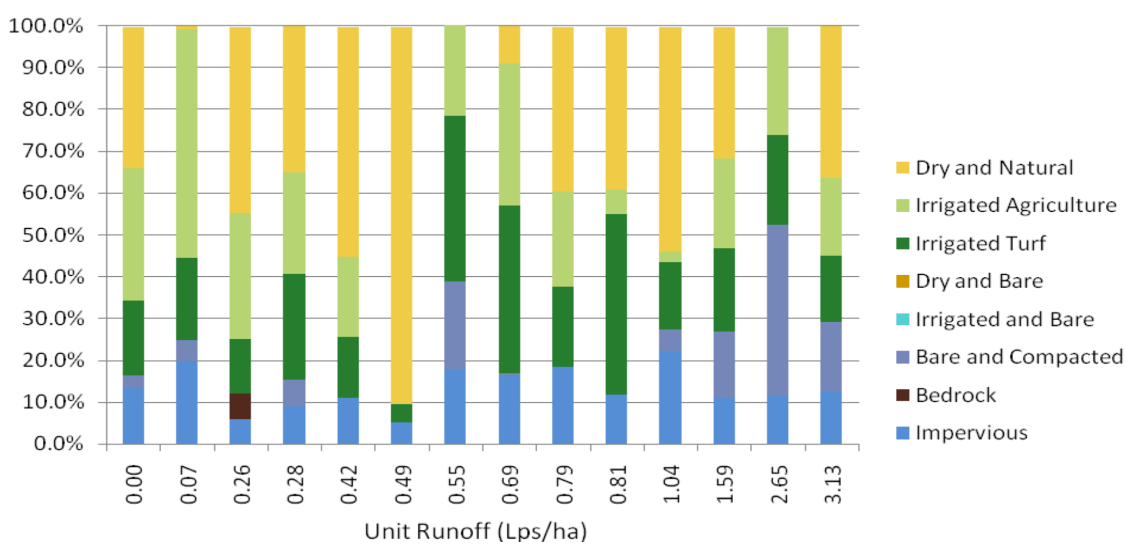


Table 4.4-2

LID Land Use / Soils Conditions - Percent of Total Area										
URA ID	Unit Runoff (Lps/ha)	Area (ha)	Bare and Compacted	Bedrock	Dry and Bare	Dry and Natural	Impervious	Irrigated Agriculture	Irrigated and Bare	Irrigated Turf
375	0.07	61.6	5%			1%	20%	55%		20%
578	0.79	69.2				40%	18%	23%		19%
653	1.59	85.4	16%			32%	11%	21%		20%
679	0.81	3.7				39%	12%	6%		43%
989	3.13	15.1	17%			36%	13%	19%		16%
1285	0.28	109.3	7%			35%	9%	24%		25%
1346	0.55	9.1	21%			1%	18%	30%		40%
1399		106.4	3%			34%	13%	32%		18%
1495	1.04	19.7	5%			54%	22%	3%		16%
1642	0.42	42.7				55%	11%	19%		15%
1825	0.26	70.5		6%		45%	6%	30%		13%
1931	0.69	40.7	1%			9%	16%	34%		40%
1959	2.65	7.7	41%				12%	26%		22%
1963	0.49	60.8				90%	5%	0%		5%
Min	**0.00**									
Avg	**0.91**	50.1	8%	0%		34%	13%	23%		22%
Max	**3.13**									

Figure 4.4-3 LID Land Use / Soils Distribution

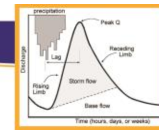


The objective is to recommend a unit discharge rate which represents a realistic, 10 year return period peak flow rate under pre-development conditions. The above analyses were completed using the 100 year design storm. Note that in both cases, there were instances of zero runoff. Also note that there is no clear correlation between the amount of imperviousness and unit runoff rates – catchment imperviousness of greater than 10% had unit runoff rates across the full spectrum of values. The reason for this apparent anomaly is that in some of the subject catchments, the impervious areas are relatively close to the flow measurement location, while in others with a similar land use mix, the imervious areas are further away. When the impervious areas are closer to the flow measurement location, surface runoff generated on them has little time to infiltrate as it passes over the pervious areas.

If the above analyses were conducted using the 10 year design storm, one would expect that the average unit runoff would be significantly less than the 0.65 Lps/ha derived using the 100 year storm. One could also argue that the few high values skew the averages significantly. (The median unit runoff rate under existing conditions is only 0.28 Lps/ha). These arguments suggest that for the 10 year, pre-development conditions, the unit runoff rate might be only 0.1 or 0.2 Lps/ha. Such a low value, however, might also be too restrictive, resulting in on-site requirements which are too onerous for the developer to bear. Some level of discharge should be provided since it isn't always feasible to completely dispose of runoff on-site. In order to balance these issues, it is proposed that the minor system (10 year) flows should be controlled to an effective maximum discharge rate of 0.5 Lps/ha.

In most cases, major runoff is not controlled. This assumes that the major drainage routes can adequately accommodate these flows. This may be true for smaller developments which drain to well established routes. However, a couple of larger development areas (Rattlesnake Mountain and Jersey Lands, for example) are several kilometers from receiving waters that could accommodate uncontrolled 100 year peak flow rates. In most cases, the major drainage routes between the developments and the receiving waters, are natural channels or streams. It is not a viable option to increase the hydraulic capacity of these natural channels for a variety of reasons. Nor is it economically feasible to construct kilometers of large-diameter trunk storm sewers. Therefore, such developments should be charged with attenuating their 100 year post-development peak flow rates to an appropriate level.

Analysis indicates that if LID methods are implemented during development, the resulting 100 year peak flow rates can be accommodated by existing drainage routes. **Table 4.4-2** indicates that the average unit runoff rate under LID conditions is 0.91 Lps/ha. Rounding up, it is therefore proposed that the major system (100 year) flows be controlled to an effective 1.0 Lps/ha. This allows the developer to decide how to manage their stormwater on-site – either by implementing LID principles, or by using conventional systems. In both cases, the downstream peak flow rates should be similar.



Summary:

1. For all developments, it is proposed that post-development runoff be attenuated to a maximum of 0.5 Lps/ha for 10 year events or less, and
2. For developments where upgrading downstream major drainage routes is not feasible, the post-development runoff be attenuated to a maximum of 1.0 Lps/ha for up to the 100 year conditions.

5.0 BASIN DRAINAGE PLANS

This section of the Summerland Master Drainage Plan presents the interpretations, options, proposed works, and estimated capital costs associated with each of the primary drainage basins within the study area based on the analyses outlined in **Section 4.0**.

There are eleven sub-sections, one for each of the primary basins shown in **Figure 1.1**. Within each sub-section, are five further divisions that address:

- existing drainage
- both existing and future land use
- infiltration potential
- analysis results
- proposed projects to correct either existing or anticipated deficiencies

Each section is also accompanied by an index map that shows:

- the subject basin within its context
- key infrastructure types and locations
- proposed project locations

Additional figures are also included which show:

- existing and propose infrastructure, including reference IDs and diameters where applicable
- natural drainage routes (ravines, swales, gullies)
- sub-catchment boundaries and reference IDs
- contours
- existing sinks (surface depressions where water could pond)
- proposed land use (existing land use is inferred from ortho photos)
- soils drainage characteristics

Each proposed project is presented in its own sub-section and includes:

- assigned priority
- implementation trigger
- 100 year design flow

- estimated capital cost
- background discussion that explains why the project is required
- upgrade or improvement concepts
- description of the proposed works
- suggested implementation strategy
- cost estimation spreadsheet or spreadsheets (if LID and/or Conventional works are different) – Phase 2 projects only

As discussed in **Section 2.0**, the *Master Drainage Plan* provides general concepts for addressing stormwater management within the study area. The projects presented in the following sections provide reasonable solutions, but should not be implemented without first obtaining site-specific information and completing detailed analysis and design using that information.

5.1 Prairie Creek Basin

Although the Prairie Creek Basin is the second-largest by area within the District, it is probably the most important because of the following:

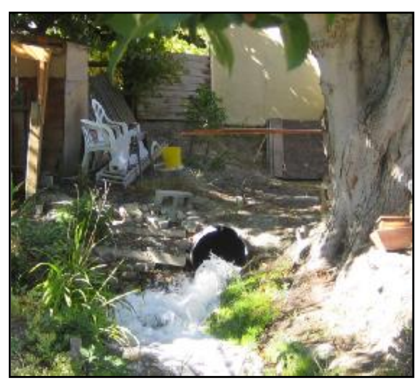
- The reach extending through Lower Town to Okanagan Lake is a recognized fish spawning area.
- It passes through, and drains much of the downtown area.
- A significant amount of future development is anticipated within the upper part of the basin.

For these and other reasons, the District decided that this basin would be the first to have a Master Drainage Plan.

5.1.1 Existing Drainage

The primary source of flow in Prairie Creek is leakage from the Trout Creek Reservoir. Water from Trout Creek is diverted to this reservoir, located at the west end of the Prairie Creek Basin, and is the primary water supply for the District of Summerland. A 1995 study by GeoViro Engineering Ltd. estimates the loss from the reservoir to Prairie Creek "to be in the range of 4500 – 45000 m^3/d". This translates into an average flow rate ranging between 0.052 – 0.520 m^3/s. Simple field measurements at various locations along the stream confirm this estimate, with inferred summertime flow at the south end of Sinclair Road of approximately 0.15 m^3/s. The flow in Prairie Creek never stops, and based on conversations with Staff and local residents, does not fluctuate significantly upstream of the downtown area.

The average gradient of Prairie Creek between the Trout Creek Reservoir and Rippen Avenue is approximately 3.5%. From Rippen Avenue to Prairie Valley Road (at the northeast corner of Giant's Head Elementary School), the average gradient is approximately 0.7%, and pass through agricultural land (orchards and meadows). The road sections are, for the most part, rural in nature. There are a few very small piped drainage systems which primarily collect ground water and transport it out of low spots on roads.



There is an ephemeral tributary to Prairie Creek which originates in the southern part of the basin and joins the main stream near Lumsden Avenue and Dale Meadows Road. It appears to contain flow only during the annual snow melt. A second tributary joins Prairie Creek at the southeast corner of the Giant's Head Elementary School. Flow in this tributary appears to be also generated from ground water, and is present year-round. Field measurements indicate that the base flow rate in this small tributary is less that 0.10 m^3/s.

Downstream of the Giant's Head Elementary School, Prairie Creek becomes significantly constricted by development as it passes through private property. The most critical reach is between Phinney Avenue and Brown Street. After this, there is a brief section of open channel stream, then Prairie Creek enters a 900 mm diameter storm trunk located on Prairie Valley Road. Note that during winter, ice build-up in the creek causes on-going operational issues.

The storm trunk on Prairie Valley Road was installed in 1997 as part of the sanitary sewer project, and replaces an older 600mm diameter storm sewer which is still used as the storm sewer for the road. These two trunks discharge into the west ditch along Highway 97. From there, it crosses the highway through a 1200 mm diameter culvert and careens along the silt bluffs to a control structure at the west end of Butler Street.

The control structure was constructed in 1997 to provide a safer overflow route to Okanagan Lake. Two sluice gates allow a limited flow into the original channel, which flows through private properties until it reaches the lake. This channel consists of alternating open channel and closed pipe reaches of various sizes and capacities. The overflow pipe on Butler Street has a diameter of 1350 mm, and extends straight to the lake past the sanitary lift station.

5.1.2 Land Use

Existing

The Prairie Valley Basin is comprised mostly of either agricultural or natural land uses. More urban-style land uses start on the east side of Cartwright Mountain, and continue down to the lake. These can be clearly seen in **Figure 5.1-2**.

Within the residential areas, many of the streets have a rural cross section – gravel or grass shoulders; no curb and gutter. Where the streets do have an urban cross section (curb and gutter), much of the drainage is accomplished using drywells. Only a small portion of the developed areas have storm sewer systems which discharge directly to Prairie Creek.

It is worthwhile to note that there are many areas where natural conditions preclude any uses other than for preservation, and perhaps recreation. These include, but are not limited to:

- the silt bluffs along the lower reaches of Prairie Creek (east of Highway 97)
- rocky slopes on Giant's Head Mountain.

Future

Most of the potential development within the Prairie Creek basin is projected to be primarily low-density residential, located as shown on **Figure 5.1-2**. Pockets of higher density residential and commercial development are also projected for the downtown and Lower Town areas. It is assumed that land within the ALR (except perhaps for the proposed Brandenburg development at the west end of the basin), will remain agricultural.

The impacts of these potential developments on Prairie Creek must be managed, and are discussed in more detail in projects sections for Prairie Creek Basin.

5.1.3 Infiltration Potential

Surficial Soils

The Prairie Creek Basin is characterized by three of the four SCS Soil Groups, which are shown in **Figure 5.1-3**. Catchments which are comprised mainly of Soils A and B are considered the most suitable for stormwater disposal to ground using infiltration methods. Catchments comprised mostly of Soil C may be suitable provided appropriate measures are taken. If Low Impact Development (LID) strategies are to be used in these catchments, then amended soils will probably be required in the developments.

Groundwater Conditions

There are many areas where groundwater seeps to the surface. Much of this seepage at the western end of the basin is due to leakage from the Trout Creek Reservoir. However, there are also other areas where the ground water is a natural occurrence. An area of well-documented groundwater problems is located south and west of the Giant's Head Elementary school. The groundwater table in this area is very close to the surface, and ditches and footing drains contribute to the Prairie Creek base flows.

Fortunately, most groundwater discharge areas are located within the rural, agricultural areas, where small collection systems address local inconvenience issues. In potential development areas, groundwater limits the potential to use infiltrate methods for stormwater management. These issues will have to be addressed through detailed hydro-geotechnical investigations and design during the development approval process.

5.1.4 Analysis

This basin presents several stormwater management challenges:

- It contains a stream that flows year round with a significant base flow;
- Most of the stream has been enclosed in pipes within its lower reaches, establishing a fixed maximum capacity;
- The mid and lower reaches of Prairie Creek pass through highly-developed, high-value areas that contain large amounts of hard surfaces such as buildings and paved parking lots;
- The lower reach just upstream of the lake is a prime fish spawning area.

The primary analytical challenge was to determine how much Prairie Creek would be impacted by potential development, depending on the stormwater management approach adopted by the District. We already know that there have been historical instances of flooding in certain areas, but to only a limited degree. We also know that because of the agricultural and undeveloped nature of the upper portion of the basin, the creek responds only slightly to rainfall events.

Note that the potential to construct a large detention facility, just upstream of where development begins to constrict Prairie Creek, was not modeled. It was, however, considered. The conclusion is that if high peak flow rates are allowed to enter Prairie Creek at its upper reaches, significant damage could occur within the stream channel before these flows ever reached the detention facility. The alternative would be to upgrade the entire channel length from the potential detention site to the western end of the basin. Neither of these options seemed feasible nor desirable. Therefore, the base assumption is that measures would be taken within the potential develop sites to limit all flows to Prairie Creek, including runoff from the 100 year event. This includes the conventional system scenario, but recognizes that with conventional curb and gutter, there is a higher chance of runoff moving off-site than with LID methods.

5.1.5 Projects

The remainder of this section presents the details of each proposed improvement or issue within the Prairie Creek basin. Although figures are included for each project, a better understanding of the context may be obtained by referring to **Figures 5.1-P1 to 5.1-P7** at the end of this sub-section.

Note: When works are proposed in a stream, appropriate permits must be obtained from the ministry of Environment. The associated restrictive windows of operation allow few opportunities per year to complete the works, so adequate planning and preparation must be completed well in advance to ensure each project is executed smoothly and in a timely fashion.

Project: PV1 Doherty Avenue & Prairie Valley Road: Denike to Lister

Priority: 2

Trigger: Development in the portion of the Prairie Creek Basin which is located to the northwest of the Doherty and Denike intersection.

Design Flows:

	Existing	Conventional	LID	
10 year	0.0	n/a	0.007	m^3/s
100 year	0.0	n/a	0.011	m^3/s

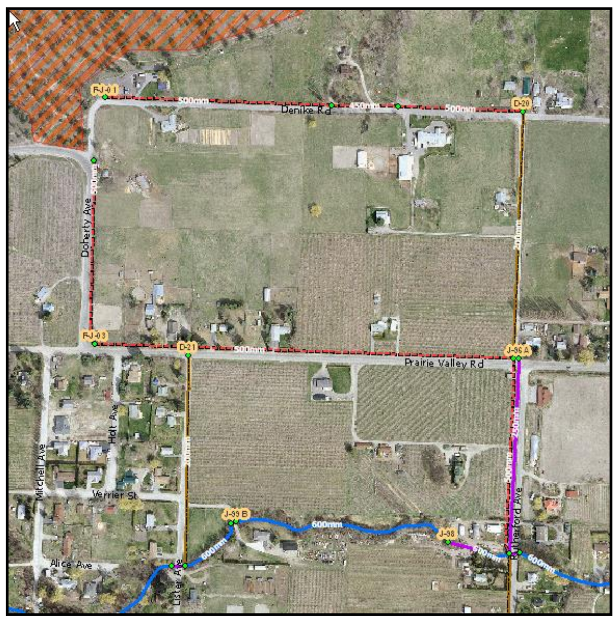
Estimated Capital Costs:

Existing	Conventional	LID
n/a	$ 153,200	$153,200

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:

Significant development is proposed within the catchments upstream of Doherty Avenue, and conceptual servicing plans have already been submitted to the District. While the minor system flows are expected to be managed on-site, major system runoff would likely reach Doherty Avenue along any future roads into the area. These flows must be safely directed to Prairie Creek.



Analysis indicates that currently, no runoff is produced out of the subject catchments. This appears to be due to the high infiltration capacity of the surficial soils, and the fact that there are no impervious surfaces which are directly connected to a drainage system discharging into Prairie Creek. Once development occurs, however, these conditions would change. The Developer has proposed to use LID concepts for stormwater management, and therefore no conventional system was modeled for this area.

Existing System:
No existing deficiencies are noted.

Conventional System:
Based on preliminary concepts submitted by the Developer, stormwater management within the proposed development upstream of the subject site would be based on LID concepts. Therefore, works for this scenario are the same as those outlined in the LID scenario below.

LID System:
Concept
The subject area is rural in nature, and will likely continue to be rural. Therefore, a ditch to transport the anticipated flows to Prairie Creek is a feasible option. Because the land slopes eastward from Doherty, the ditch would have to remain on its west side. This will require culverts across:

- the future access road at Doherty, and
- Doherty at Prairie Valley.

While it may be possible to direct flows along Holt to Prairie Creek, it seems more feasible to continue the ditch along Prairie Valley Road to Rutherford Avenue. The reasons for this are as follows:

- The ditch along Holt would have to remain on the west (higher) side of the road, and there are several driveways on this side.
- Runoff from Denike and Rutherford (see **Project PV2**) must also be directed to Prairie Creek, therefore it seems more economical to construct only one structure rather than two.

This route minimizes the number of culverts required in total (considering PV1 and PV2). However, a culvert will be required across Prairie Valley at Rutherford, as well as across 8 driveways.

Proposed Works
The grades are not that steep, so re-vegetation should provide adequate erosion protection for the ditches. The proposed works are outlined as follows:

- 1 km of trapezoidal ditch, assumed depth of 0.5 m and minimum base width of 1.0 m.
- 11 - 450 mm diameter culverts, complete with headwalls at each end.

Implementation
These works should form part of the offsite works associated with any development in the area.

Project: PV2 **Denike Street & Rutherford Avenue: Doherty to Prairie Creek**

Priority: **2**

Trigger: Development in the portion of the Prairie Creek Basin which is located to the north of Denike Street.

Design Flows:

	Existing	Conventional	LID	
10 year	0.0	n/a	0.021	m^3/s
100 year	0.0	n/a	0.028	m^3/s

Estimated Capital Costs:

Existing	Conventional	LID
n/a	$64,400	$64,400

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:

Significant development is proposed within the catchments upstream of Denike Street. While the minor system flows are expected to be managed on-site, major system runoff would likely reach Denike along any future roads into the area, as well as via the natural ravine that intersects the road. These flows must be safely directed to Prairie Creek.

Analysis indicates that currently, no runoff is produced out of the subject catchments. This appears to be due to the high infiltration capacity of the surficial soils, and the fact that there are no impervious surfaces which are directly connected to a drainage system discharging into Prairie Creek. Once development occurs, however, these conditions will change. The Developer has proposed to use LID concepts for stormwater management, and therefore no conventional system was modeled for this area.

Existing System:
No existing deficiencies are noted.

Conventional System:
Based on preliminary concepts submitted by the Developer, stormwater management within the proposed development upstream of the subject site would be based on LID concepts. Therefore, works for this scenario are the same as those outlined in the LID scenario below.

LID System:
Concept
The subject area is rural in nature, and will likely continue to be rural. Therefore, a ditch to transport the anticipated flows to Prairie Creek is a feasible option. Because the land slopes south and east from Denike, the ditch would have to remain on its north side. Available topography indicates that there may be a short reach requiring a culvert to ensure flows can be routed through a very flat or slightly high point as shown. Detailed survey may indicate that a ditch is feasible through this reach, but for now, we'll assume a culvert will be required. A culvert will also be required across Denike at Rutherford.

This drainage system would tie into the system proposed in **Project PV1** at Prairie Valley and Rutherford.

Proposed Works
The grades are not that steep, so re-vegetation should provide adequate erosion protection for the ditches. The proposed works are outlined as follows:

- 760 m of trapezoidal ditch, 0.5 m deep with a minimum base width of 1.0 m
- 90 m of 450 mm diameter CSP, complete with headwalls at each end
- 3 - 450 mm diameter culverts, complete with headwalls at each end.

Implementation
These works should form part of the offsite works associated with any development in the catchments above Denike Street.

Project: PV3 **Prairie Creek: West of Sinclair**

Priority: **2**
Trigger: Significant development upstream of the subject location.

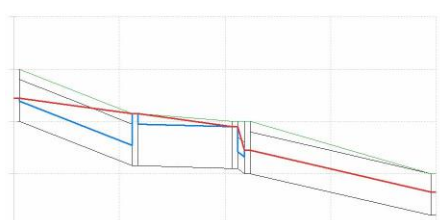
Design Flows:	Existing	Conventional	LID	
10 year	0.14	0.27	0.27	m^3/s
100 year	0.45	0.75	0.75	m^3/s

Estimated Capital Costs:	Existing	Conventional	LID
	n/a	$22,000	$22,000

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:

As Prairie Creek nears the more developed portion of town, its profile starts to flatten-out. As shown in the adjacent plot, there is potential for the capacity of the creek channel to be exceeded under post-development 100 year runoff conditions. The analyses indicate that even under existing conditions, the 100 year runoff comes very close to channel capacity at the



subject reach.

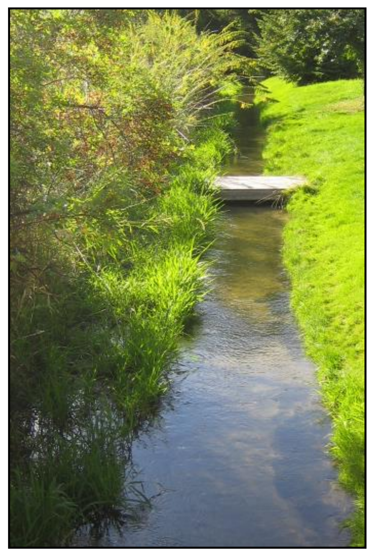
The profile data for the analyses were extracted from the available contour data. Note that the overflow occurs at the upstream end of the flattest reach, while there is sufficient capacity in the steeper, downstream reach. This indicates that channel capacity in these flatter reaches is very sensitive to slope. More accurate channel data would be required to determine if there really would be a capacity problem under the design peak flow conditions.

Existing System:
The subject channel operates at capacity under existing design flow conditions.

Conventional System:
Most of the development upstream of the subject reach on Prairie Creek is likely to use LID stormwater management methods. Only a portion of the development on Cartwright Mountain might want to use conventional drainage systems. However, runoff from this area will require attenuation on-site, and the discharge will still be routed over pervious areas making the impact to Prairie Creek negligible. Therefore, the works outlined in the LID System section below will be adequate for the Conventional System scenario as well.

LID System:
Concept
Even with LID implementation, increased 100 year runoff from anticipated development will still have an impact on Prairie Creek. There are therefore only two general options:

- attenuate the peak flow rates (on-site or somewhere downstream), or
- increase the channel capacity.



Considering that the existing conditions are close to capacity anyway, a detention facility would have to discharge at a very slow rate to avoid increasing stream flows too much. Under 100 year runoff conditions, this would require significant storage volume. Since we are considering 100 year runoff conditions, the most feasible location would be somewhere on the stream channel, downstream from the development area. This would mean either purchasing or leasing agricultural land for flow attenuation purposes.

An easier and more economical solution would be to upgrade the channel capacity. Increasing capacity at this location will not cause problems downstream since potential trouble-spots are addressed by some of the other projects identified for the Prairie Valley Basin.

Proposed Works

Since the stream profile is relatively flat through the subject reach, deepening it is not an option. Therefore, the only effective ways of increasing channel capacity is to either widen it, construct berms on both sides, or do a combination of both. Berms take up approximately as much additional land as widening the channel does, so we've chose the widening option for capital cost estimating purposes. The proposed works are therefore as follows:

- widen approximately 420 m of existing channel from approximately 1.2m to 2.7m

Implementation

The proposed works are not required until a significant amount of development has occurred upstream of the subject site. A simple water level gauge, which indicates the maximum water level that has occurred since the last reading, should be installed now. It should be checked and reset after every large rain storm to develop a better understanding of how the stream responds in this reach to large rainfall events. The proposed works can be completed once it is evident that stream flows following large rain storms are consistently higher than historical levels. An example of such a gauge is shown in **Appendix D**.

Prior to actually increasing the channel capacity, it would be beneficial to conduct a detailed topographical survey of the subject reach. This should include sufficient data to accurately determine the channel profile and representative cross sections. The survey should extend several meters away from the stream on both sides of the channel to ensure that the floodplain can also be defined accurately. Ground elevations at buildings adjacent to the stream channel should be included.

Project: PV4 Prairie Creek: South of Giant's Head Elementary

Priority: 2

Trigger: Significant development upstream of the subject location.

Design Flows:

	Existing	Conventional	LID	
10 year	0.14	0.27	0.27	m^3/s
100 year	0.45	0.76	0.76	m^3/s

Estimated Capital Costs:

Existing	Conventional	LID
n/a	$67,500	$67,500

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:
The profile for the two existing 600mm culverts (reach J-86 to J85) is very flat – slope is approximately 0.1 to 0.2%. Analysis indicates that under post development conditions, 100 year peak flows exceed the capacity of this reach.

Existing System:
The existing system has adequate capacity for anticipated peak flows under existing conditions.

Conventional System:
Since little conventional systems are anticipated to be used upstream of this site, the proposed concept under this scenario is the same as that proposed for the "LID System" scenario below.

LID System:
Concept
Since the profile for this reach is so flat, and the open channels on either end are relatively shallow, there is little opportunity to install a culvert with a diameter larger than 600mm. Therefore, a third 600mm diameter culvert is proposed. Analysis confirms that this is adequate to accommodate the anticipated design flow.

Proposed Works
The proposed works are:

- 140m of 600 mm CSP culvert, including head walls at both ends.

Implementation
The proposed works are not required until a significant amount of development has occurred upstream of the subject site. The current project should be completed in conjunction with Project PV3. See Project PV3 for more information.

Project: PV5 **Prairie Valley Road: Phinney to Brown**

Priority: **1**
Trigger: Existing deficiency.

Design Flows:	Existing	Conventional	LID	
10 year	0.20 (n/a)	0.34 (0.089)	0.34 (0.089)	m^3/s
100 year	0.48 (n/a)	0.96 (0.71)	0.96 (0.71)	m^3/s

Note: Two peak flow rates are given as follows: works u/s of proposed diversion (by pass works). The flows to the existing system will remain at current base-flow levels.

Estimated Capital Costs:	Existing	Conventional	LID
	$554,400	$1,019,100	$1,019,100

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:

Prairie Creek enters a constricted series of reaches when it meets Prairie Valley Road at the northwest corner of the Giant's Head Elementary property. It enters a 600 mm piped section which crosses Prairie Valley Road and continues down Phinney Avenue. Between Phinney and Brown Street, the stream alternates between a narrow open channel and storm sewers exhibiting a variety of diameters.

Analysis indicates that the 100 year peak flow generated under current development conditions would exceed the existing system's capacity. This deficiency is only exacerbated under the future development scenarios.

Historically, flows in this reach have also exceeded channel capacity, primarily at the culvert across Saunders Crescent. The return period of this historical event is unknown.

As shown in the adjacent image, the inlet to this system is fairly restrictive, subject to blockage by debris, and in relatively poor condition.

The 1995 *Storm Drainage Study* also identified this deficiency and recommended a by-pass on Prairie Valley Road from Phinney Avenue to Brown Street. It recommended a 1200mm diameter bypass based on an existing 100 year peak flow rate of 3.5 m^3/s. As noted in the Design Flows table above, current analysis yields significantly lower 100 year peak flow rates. The difference is attributed to the fact that the 1995 study used the Rational Method for peak flow estimation. This is a simplistic method that is applicable to only very small catchments (usually under 10 hectares). The InfoSWMM model used for the current *Master Drainage Plan* analyses takes into consideration the effects of infiltration, disconnected impervious areas, catchment slopes, and channel storage. Therefore, the diameters proposed for each of the scenarios outlined below are less than originally estimated.

Existing System:

Concept

The existing system has capacity for a peak flow rate of approximately 0.33 m^3/s. Due to the number of private properties through which the stream flows, it is considered economically infeasible to upgrade channel widths or to install a larger diameter storm sewer within the existing alignment. Therefore, the Prairie Valley Road bypass is better solution.

Proposed Works

The bypass must accommodate all flow in excess of the 0.33 m^3/s. Based on our analysis, a minimum diameter of 450 mm is required to accommodate the excess 100 year peak flow rate under existing development conditions.

Note that the inlet works to the diversion must be sized to accommodate the full design peak flow rate, and are sized accordingly.

The proposed works are as follows:

- 530 m of 450 mm diameter storm sewer (bypass)
- 45 m of 750 mm diameter storm sewer (inlet works)
- 450 mm diameter outlet structure, complete with safety grill
- 750 mm diameter inlet structure, complete with safety grill
- one diversion structure

Implementation

See LID System comments below.

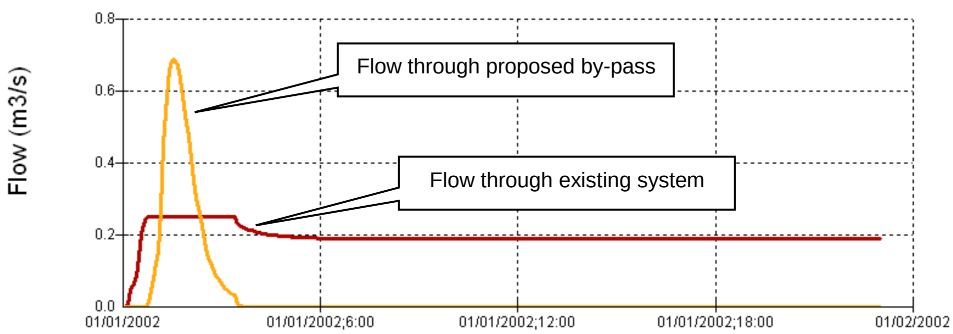
Conventional System:

The 100 year design flow under this scenario is only slightly higher than that for the LID scenario. Analysis indicates that the required works are the same as those for the LID scenario outlined below.

LID System:

Concept

As shown below, the bypass is even more necessary under future development conditions. The only difference is the size of the proposed works.



Proposed Works

Since the design flow under these conditions is larger than under existing conditions, the proposed inlet and diversion works will have larger diameters as follows:

- 530 m of 750 mm diameter storm sewer (bypass)
- 45 m of 900 mm diameter storm sewer (inlet works)
- 750 mm diameter outlet structure, complete with safety grill
- 900 mm diameter inlet structure, complete with safety grill
- one diversion structure

Implementation

Since this is an existing deficiency which could impact several homes, these works should be constructed as soon as the District can set-aside the funds. If other utility or road upgrades are planned for this stretch of Prairie Valley Road, it would be prudent to combine the works for cost savings.

Project: PV6 **Prairie Creek: Brown to Armstrong**

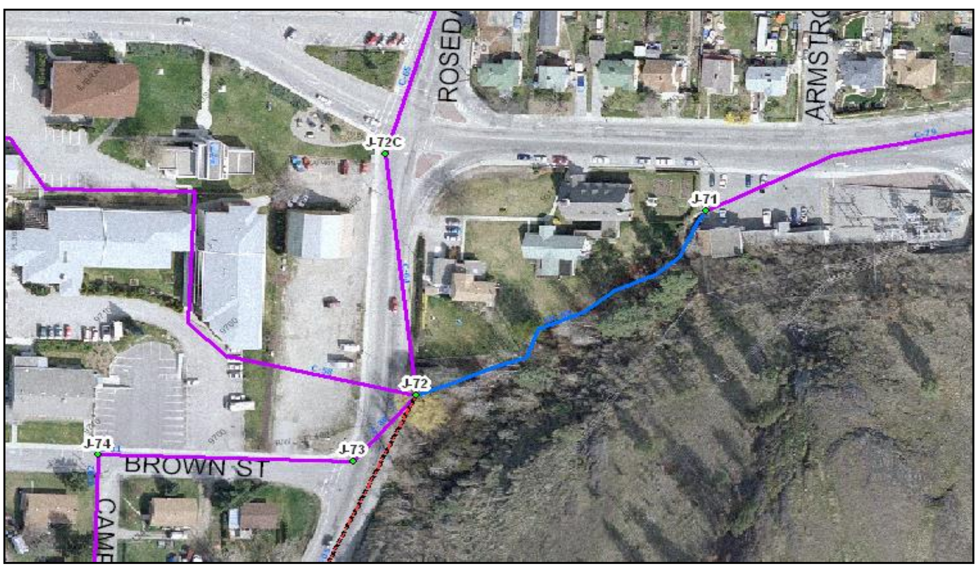
Priority: **2**

Trigger: There are some minor existing deficiencies. The major works, however, would be triggered by significant upstream future development.

Design Flows:	Existing	Conventional	LID	
10 year	0.21	0.35	0.35	m^3/s
100 year	0.49	0.98	0.98	m^3/s

Estimated Capital Costs:	Existing	Conventional	LID
	$43,700	$60,600	$60,600

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
Prairie Creek flows through an open channel reach between Brown Street and Prairie Valley Road near Armstrong Avenue. There are three existing pipe discharges located at the upstream end of this reach:

- the 600 mm trunk storm sewer off Brown Street,
- the 250 mm storm sewer off the parking lot, and
- the 300 mm storm sewer off Rosedale Avenue.

A fourth discharge is anticipated from the proposed by-pass trunk sewer (see **Project PV5**).

The channel section varies significantly along the length of this reach, starting relatively wide and shallow at the upstream end, and becoming confined and deep at the downstream end. There is evidence of erosion along the north bank near the storm sewer outlets, suggesting high flow rates at times. Only one of the outlets is visible beneath the tangled vegetation. This channel is poorly maintained and is a potential source of debris to block the inlet to the 900 mm trunk storm sewer on Prairie Road.

Analysis indicates that there is sufficient capacity within the existing channel to accommodate the 100 year peak flow from existing development. However, under future development conditions, overflow is anticipated.

Existing System:
Concept
Since the channel has adequate capacity for existing flow rates, the only works that would be required are more maintenance-oriented. The outlets from the existing storm sewers should be located and equipped with proper outlet structures. The north bank should also be stabilized to prevent further erosion.

Proposed Works
The proposed works are as follows:

- locate existing 600 mm storm sewer from Brown Street and install outlet structure
- locate existing 250 mm storm sewer from the parking lot and install outlet structure
- locate existing 300 mm storm sewer from Rosedale Avenue and install outlet structure
- install rip rap over a geo-textile to stabilize and protect approximately 10 m of north stream bank.

Implementation
These works should be completed as soon as the District can set-aside the funds.

Conventional System:

Concept

In addition to the works outlined in the Existing System section above, the channel capacity must be increased to accommodate the estimated 100 year peak flow rate under the subject development conditions. The channel slope through this reach is somewhat conducive to increasing channel depth, but there is also opportunity to increase channel width within the upper portion of the reach.

Proposed Works

In addition to the works outlined in the "Existing System" scenario above, the following works are also proposed:

- Widen approximately 120 m of existing channel by an additional 1.0 meter.
- Stabilize approximately 40 m of bank with a root reinforcement system and re-vegetate.

Implementation

These works are not required until significant upstream development occurs.

Note that a detailed topographical survey of the subject reach should be completed prior to detailed design. This should include sufficient data to accurately determine the existing channel profile and representative cross sections. The survey should extend several meters away from the stream on both sides of the channel to ensure that the floodplain can also be defined accurately. Ground elevations at buildings adjacent to the stream channel should be included. This information will be required to determine:

- The amount of widening and or deepening necessary, and
- Where erosion and/or channel down-cutting might occur, requiring special treatment.

LID System:

Since the design 100 year flow rates for the LID and conventional scenarios are similar for this reach, the works and implementation proposed above are also applicable to the LID scenario.

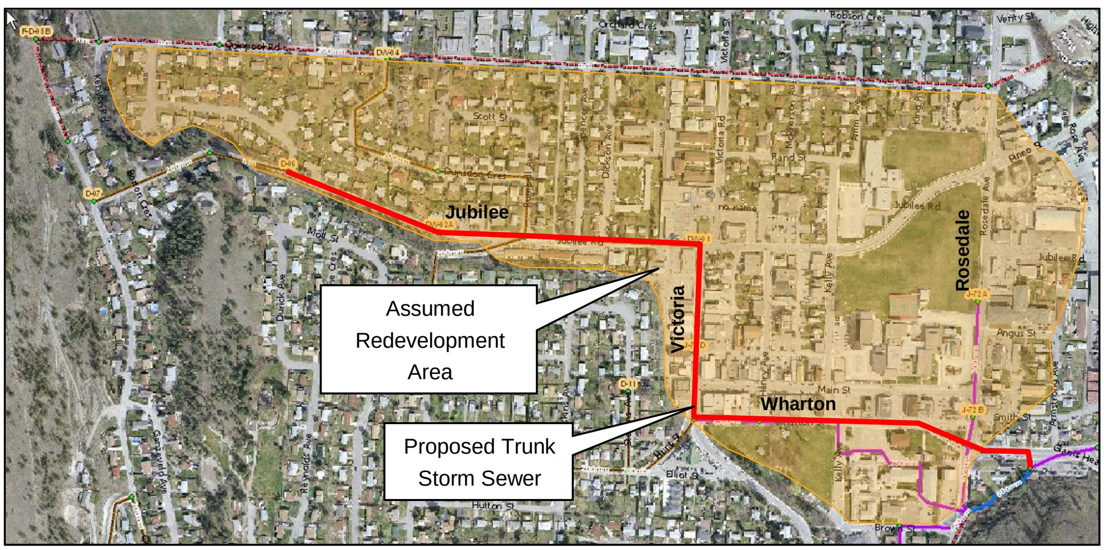
Project: PV7 **Downtown: Jubilee to Prairie Valley**

Priority: **3**
Trigger: Significant densification of the downtown area.

Design Flows:	Existing	Conventional	LID	
10 year	n/a	.067	.037	m^3/s

Estimated Capital Costs:	Existing	Conventional	LID
	n/a	$2,655,400	$1,626,800

Note: *Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.*



Issue:

The 1995 *Storm Drainage Study* proposed a trunk storm sewer through the downtown region to improve collection and convey the runoff to either Eneas Creek or Prairie Creek. The identified route would extend from Marshall Crescent at Jubilee Road to Prairie Creek at Armstrong Avenue. The recommended diameters range from 750 to 900mm.

Currently, the subject area is serviced by many drywells, and a small storm sewer. Few of the streets have full urban cross sections. When discussing historical drainage problems with Staff, none were identified for the subject area. This isn't surprising since the soils in this area have relatively high infiltration characteristics.

It is anticipated, however, that in the future, much of the downtown area will be redeveloped into higher density residential and more commercial land uses. Under these circumstances, the amount of impervious area will increase, resulting in higher runoff potential. The redevelopment will likely include upgrading existing rural streets to a full urban standard.

Because of these potential changes, the need for a trunk sewer to service the area has been confirmed. It should be located in a way that will allow lateral storm sewers to be connected as development proceeds and roads are upgraded.

Existing System:
There are currently no existing deficiencies identified within the subject area, and therefore no works have been identified under this scenario.

Conventional System:
Concept
As outlined in project PV9, it would be better to drain Quinpool to Eneas Creek rather than to Prairie Creek. Therefore, the proposed storm trunk sewer is anticipated to service only the area bounded by Quinpool, Jubilee / Wharton, and Rosedale. The key assumption in this scenario is that:

- the amount of total impervious area will increase to a minimum of 60%, and that
- 35% of that will be directly connected to a storm sewer.

This reflects the assumptions that:

- there will still be some "green space" – pervious areas - preserved
- on-site detention (underground and on roof-tops) will be employed.

This trunk storm sewer is sized to accommodate only the 10 year runoff – excess runoff must be routed to Prairie Creek on the road surface.

Note that under this scenario, flows in Prairie Creek rise to where they slightly exceed the capacity of the existing 600mm storm sewer just south of the Prairie Valley Road / Highway 97 intersection under the 100 year runoff conditions. No upgrades were recommended under these circumstances since:

- the deficiency is very slight (approximately 30 cu.m. of water overtop the manhole)

- the excess runoff would simply run along the edge of the highway until it spilled into the gulley south of the Walters Road intersection.

Proposed Works
Based on the above assumptions, the required works are as follows:

- 1450 m of 750mm diameter storm sewer, c/w manholes, curb, gutter, and catch basins
- 325 m of 600mm diameter storm sewer, c/w manholes, curb, gutter, and catch basins

Note that the section on Wharton Street and Prairie Valley Road could be reduced in size from 750mm to 675mm due to a slightly steeper slope. However, we have adopted the policy of using the upstream diameter as the minimum for the downstream section to be conservative for cost estimating purposes.

Implementation
See the implementation discussion in the LID System section below.

LID System:
Concept
Because of the potential impacts to Prairie Creek from more frequent and higher peak flow rates from the increased impervious areas in the downtown catchments, LID methods could be implemented to mitigate them. The soils in the subject area generally exhibit good infiltration characteristics, and groundwater is less of an issue. As stated in the "Existing System" section above, most of the rainfall is currently managed through drywells and surface infiltration.

While the total impervious area is still anticipated to remain at 60%, the objectives of the LID implementation are to:

- reduce the amount of impervious area which discharges directly to storm sewers, and to
- use as much infiltration disposal as possible.

The disconnection could be achieved by designing landscaping to both store and infiltrate runoff from roof leaders and parking lots. Flush curbs are not well suited to this type of development, but standard curb, gutter, and catch basins can readily be used with drywells and perforated pipes or other similar underground infiltration systems. The key here is to ensure that any excess runoff which cannot be infiltrated is transported to Prairie Creek. This would require that the infiltration system be linked by pipes or other means, depending on the system employed.

Proposed Works
For the purposes of the *Master Drainage Plan*, drywells and perforated pipe have been used instead of standard manholes and storm sewers. The proposed LID works are therefore:

- 1450 m of 600mm diameter perforated storm sewer, c/w drywells, curb, gutter, and catch basins
- 325 m of 450mm diameter perforated storm sewer, c/w drywells, curb, gutter, and catch basins

Implementation
Much depends upon the location and timing of future redevelopment within the downtown area. When the development community starts to express significant interest in the subject area, a pre-design study should be conducted to confirm the best location for the storm trunk, as well as to define the full service area and required collection system configuration.

Another potential trigger would be planned street upgrades. The trunk storm sewer should be installed if the alignment falls on a street that is to be re-done. In this case, the pre-design study should be completed prior to significant street upgrading plans.

The feasibility of using infiltration to reduce peak flows and capital costs should also be confirmed by obtaining a better understanding of the subject area's infiltration characteristics. This should be investigation should be part of the pre-design study.

Project: PV8 Prairie Creek: Highway 97 to Butler

Priority: 1
Trigger: Existing deficiency.
Design Flows: This project is not based on design flows.

Estimated Capital Costs:

Existing	Conventional	LID
$ 15,000	n/a	n/a

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:

Once Prairie Creek crosses Highway 97, it enters a steep reach that passes along the base of a relatively high silt bluff. This gorge terminates at the west end of Butler Street. While the new diversion and overflow storm sewer are sized to accommodate anticipated major peak flows, there is another concern that they do not address.

As shown in the adjacent image, the silt bluff is prone to sloughing. While most of these events appear to be minor in nature, it may be possible for a major slough to deposit debris into the stream channel. Under this scenario, water would pool behind the deposit until it builds enough head to either oveflow it, or to burst through it. In either case, a torrent of debris and water would likely block the diversion structure and send material in an unpredictable path – possible through one or more of the homes along Butler Street.

Concept:
While the probability of occurrence is low, the potential for damage is high. While it is possible to design and construct works to protect the stream channel, the costs are probably not warranted.

Another option would be to better understand the risks involved, and if necessary, develop and implement a system to provide sufficient warning to evacuate residents when a significant event occurs. Such a warning system might be comprised of sensors embedded into the silt bluff, or a water level sensor at the diversion structure. In the first case, the sensors would detect when a significant portion of the bluff sloughs off. In the second case, the sensor would detect a drastic and rapid drop in water level (the stream would be temporarily blocked). The need for, and design of such a system could be determined by a geotechnical investigation.

Proposed Works:
In order to address this issue, a geotechnical investigation should be commissioned to determine:

- the stability of the silt bluff
- the risk of a major slough
- the risk of downstream damage, and if warranted,
- the most feasible measures to protect downstream residents.

Implementation:
The District should prepare a request for proposal and commission the study as soon as the necessary funds are available. The estimated cost provided above and in **Table 6.1** is for budgeting purposes only.

Project: PV9 **Cartwright Avenue: North of Quinpool**

Priority: **2**

Trigger: Existing deficiency, but development on Cartwright Mountain (west of Cartwright Avenue) may accelerate the need for these works.

Design Flows:	Existing	Conventional	LID	
10 year	0.000	0.102	0.053	m^3/s
100 year	0.001	0.037	0.022	m^3/s

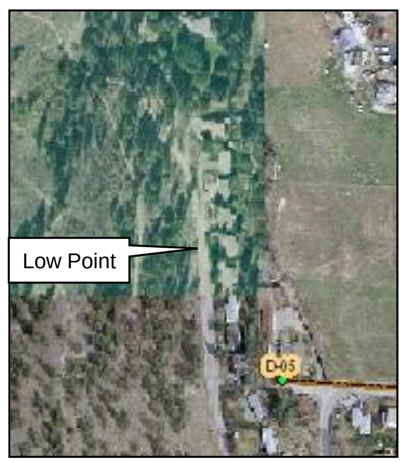
Note: The 100 year design flows are less than the 10 year design flows because they are applicable to only the first portion of the proposed works, while the 10 year flows apply to the works at the east end of Quinpool. (As the works progress eastward on Quinpool, the upgraded road section contibutes more and more runoff.)

Estimated Capital Costs:	Existing	Conventional	LID
	$225,000	$1,054,037	$1,036,500

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:

There is a low spot on Cartwright Avenue north of the Quinpool ROW. Staff have indicated that there have been occaisions when runoff from the hillside has flowed to this location, requiring sandbags to direct the runoff between the houses and onto the meadow to the east. It is likely that this runoff was generated on the road cut extending west from Cartwright Avenue.



Preliminary plans indicate that single family residential development is planned for the hillside west of Cartwright Avenue. Access to this site will be be off Cartwright Ave. This is likely to increase the amount of runoff arriving to the subject low point, especially under major runoff conditions. The challenge is how to best manage potential runoff to this site under both existing and future conditions.

Since Eneas Creek flows primarily in as open-channel stream, and therefore has more additional capacity that Prairie Creek, the preferred approach would be to direct any potential runoff to it rather than to Prairie Creek.

Referring to **Project PV10,** note that Yule Crescent, which extends south from Quinpool, ends with a cul-de-sac that has no positive drainage. If runoff enters this street, it will pond in the cul-de-sac. Therefore, it is necessary to ensure that potential flows are transported east of the Yule / Quinpool intersection.

Existing System:

Concept

The subject low point is approximately 0.8 m lower than at the Quinpool / Cartwright intersection. It appears to be feasible to re-grade Cartwright (raising the low point and cutting-down the high point) to ensure positive drainage to the Quinpool ROW. However, because of the steep bank on the east side of the existing homes, a piped system should be used to transport potential runoff from the west side of Cartwright to the north side of Quinpool as shown in the figure below.

The storm sewer could discharge to a drywell, with the potential to overflow under higher runoff conditions. The excess runoff would flow along the northern side of Quinpool. Since the soils in this area exhibit high infiltration rates, the amount of excess runoff under existing development conditions is anticipated to be very low. It should be adequately managed by the existing rural road section.

Proposed Works
In order to accommodate estimated 100 year peak flows under existing conditions, the following works are recommended:

- 130 m of road re-grading
- 275 m of 300 mm storm sewer, including manholes (Quinpool: Cartwright to Yule - 100 year flow)
- 1 - 300 mm inlet structure
- 1 drywell

Implementation
If development on the hill west of Cartwright Avenue is not anticipated for several years, the District should consider including these works as part of its annual capital improvements. Detailed survey will be required to confirm the concept and to refine the design.

Conventional System:
Concept
Under projected development conditions, the proposed access road off Cartwright Avenue would extend up the hill to the west. Drainage from this road, assuming a conventional drainage system, would then be directed back to Cartwright Avenue.

In this case, because of potential 100 year flows, Cartwright Avenue would still have to be improved and re-graded to ensure the low point was located across from the Quinpool ROW. It is assumed that the minor system would also be constructed to this location.

From this re-located low spot, a storm sewer could be extended east to terminate in a manhole on the north side of Quinpool somewhat east of the Yule Crescent intersection. It is assumed that the minor system flows within the proposed development would be attenuated to existing levels, probably using over-sized pipes within the development site. However, the 100 year peak flows are likely to remain on the road surface until they reach the low point on Cartwright Avenue. Therefore, the storm sewer on Quinpool would be sized to accommodate the 100 year peak flow rate, and an appropriately-sized inlet would be constructed on the east side of Cartwright Avenue to capture the 100 year runoff at the low point.

Other than a few drywells, there is currently no formal drainage system connecting Quinpool to either Eneas or Prairie Creek. Therefore, a few options are available for runoff disposal:

- Construct a storm sewer sized to carry the major peak flow to Eneas Creek at the east end of Quinpool.

- Construct a storm sewer on Quinpool to Eneas Creek to accommodate minor system flows – major system flows would be directed to Eneas Creek using an urban cross section on Quinpool.

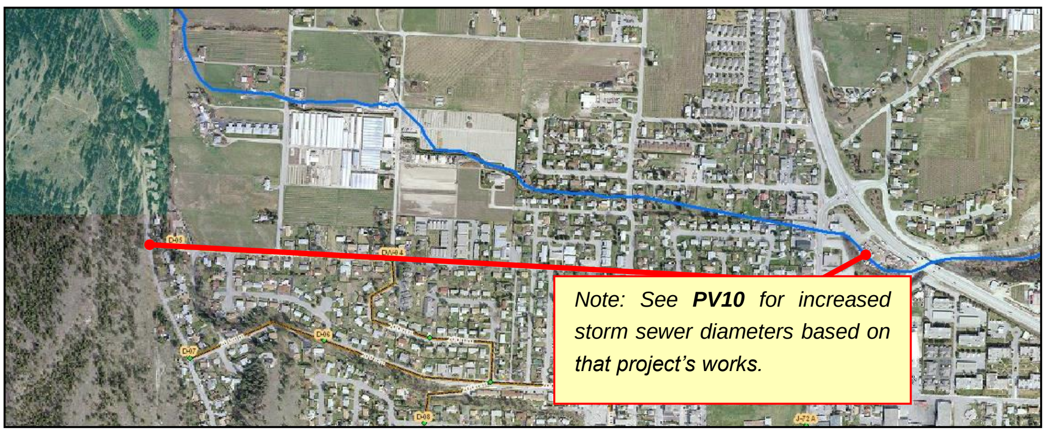
Proposed Works

For the purposes of this document, it is assumed that the more feasible option is to upgrade Quinpool to a full urban cross-section, and install a storm sewer to accommodate the minor system peak flows:

- 275 m of 250 mm storm sewer, including manholes (Quinpool: Cartwright to Yule - 100 year flow)
- 1250 m of 375 mm storm sewer, including manholes, curb, gutter, and catch basins (Quinpool: Yule to Eneas Creek - 10 year flow)

Implementation

These works would be initiated as part of the projected development on Cartwright Mountain.



LID System:

Concept

In order to minimize additional runoff to Eneas Creek, drywells and perforated pipe would be used instead of manholes and solid pipe respectively. This would allow the soils to infiltrate as much as possible, with only the excess runoff being discharged to the creek.

Proposed Works

- 275 m of 250 mm storm sewer, including manholes (100 year flow)
- 1250 m of 300 mm perforated storm sewer, including drywells, curb, gutter, and catch basins (10 year flow)

Implementation

See the implementation discussion in the "Conventional System" section above.

Project: PV10 Cartwright Avenue: South of Quinpool

Priority: 2
Trigger: Existing deficiency.

Design Flows:	Existing	Conventional	LID	
PV10 Works - 100 year	0.001	0.047	0.028	m^3/s
PV9 Works – 10 year	0.000	0.083	0.050	m^3/s
PV9 Works - 100 year	0.001	0.124	0.058	m^3/s

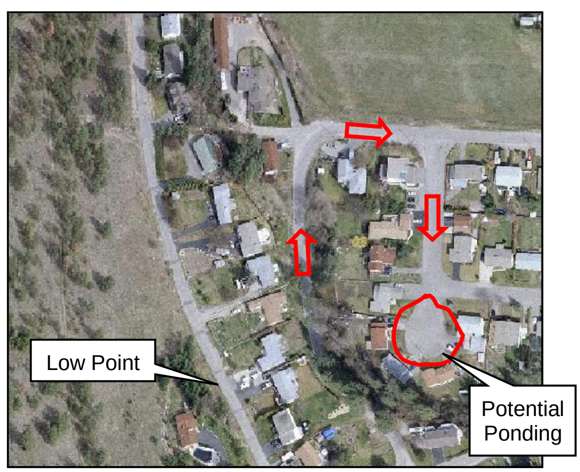
Note: The works proposed in PV10 will impact the diameter of the works in PV9. The above design flows reflect this. Also note that the 100 year design flows are less than the 10 year design flows because they are applicable to only the first portion of the proposed works. As the works progress eastward on Quinpool, the upgraded road section contibutes more and more runoff.

Estimated Capital Costs:	Existing	Conventional	LID	
	$91,300	$93,900	$91,300	*PV10 works*
	n/a	$1,129,900	$1,067,200	*Upsized PV9 works*

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:

There is a low spot on Cartwright Avenue south of Quinpool as shown. Under high runoff conditions, it would drain between the existing houses, over a steep bank, and onto Kenyon Road. The way Quinpool is graded between Kenyon and Yule Crescent, runoff would eventually flow into the cul-de-sac at the end of Yule. This cul-de-sac is also in a low spot, creating the potential for ponding under high runoff conditions.



While details are currently unavailable, it is our understanding that some developent on the hillside west of Cartwright Avenue is proposed. It is assumed that runoff from low points in the development under 100 year conditions may reach the Cartwright Avenue within the subject catchment.

Existing System:

Concept

The subject low point is too low to permit re-grading of Cartwright Avenue. Therefore, all anticipated runoff must be piped to an appropriate location. It is tempting to simply install a pipe from the low point to Kenyon Road. However, the existing houses are very close together, making this installation difficult. It would also require negotiation of an easement. There is currently no system on Jubilee Road West, so the only remaining option is to install a storm sewer from the subject low point to the Quinpool Road system proposed in **Project PV9** above.

Part of Cartwright Avenue may have to be re-graded into the hill to ensure runoff reaches the inlet rather than spilling onto the properties on the east side of the road.

Analysis indicates that the works proposed in **Project PV9** would have to be up-sized to accommodate the estimated runoff from the subject catchment.

Proposed Works
In order to accommodate estimated 100 year peak flows under existing conditions, the following works are recommended:

- 50 m of road re-grading
- 160 m of 300 mm diameter storm sewer on Cartwright Avenue (100 year flow)

The PV9 diameters proposed for the existing scenario would remain unchanged at 300mm.

Implementation
If development on the hill west of Cartwright Avenue is not anticipated for several years, the District should consider including these works as part of its annual capital improvements. Detailed survey will be required to confirm the concept and to refine the design.

Conventional System:
Concept
Since significant impacts to the subject catchment from development west of Cartwright Avenue are not anticipated, the concept for this scenario is the same as that for the Existing system scenario. The only difference is in the length of pipe in project PV9 that must be upsized as well as the proposed pipe diameters.

Proposed Works
In order to accommodate estimated 100 year peak flows under existing conditions, the following works are recommended:

- 50 m of road re-grading
- 160 m of 375 mm diameter storm sewer on Cartwright Avenue (100 year flow)
- 1 - 375mm inlet structure

The **Project PV9** works under this scenario would be:

- 275 m of 375 mm storm sewer, including manholes (Quinpool: Cartwright to Yule - 100 year flow)
- 1250 m of 450 mm storm sewer, including manholes, curb, gutter, and catch basins (Quinpool: Yule to Eneas Creek - 10 year flow)

Implementation
See the discussion for implementation in the "Existing System" section above.

LID System:

Concept

Since the primary purpose of this project is to provide a safe route for the 100 year flow, the only feasible LID methods would be to use perforated pipe and drywells instead of solid storm sewers and manholes respectively. The works proposed in project PV9 would also have to be upsized to accommodate the design flows from this project.

Proposed Works

The proposed works are therefore:

- 50 m of road re-grading
- 160 m of 300 mm diameter perforated storm sewer on Cartwright Avenue (100 year flow)
- 1 – 300 mm inlet structure

The **Project PV9** works under this scenario would be:

- 275 m of 300 mm storm sewer (Quinpool: Cartwright to Yule with 100 year flow)
- 1250 m of 375 mm storm sewer, including manholes, curb, gutter, and catch basins (Quinpool: Yule to Eneas Creek with 10 year flow)

Implementation

See the discussion for implementation in the "Existing System" section above.

Project: PV11 Victoria Road South

Priority: **2**
Trigger: Future development or Victoria Road / Dale Meadows upgrade.

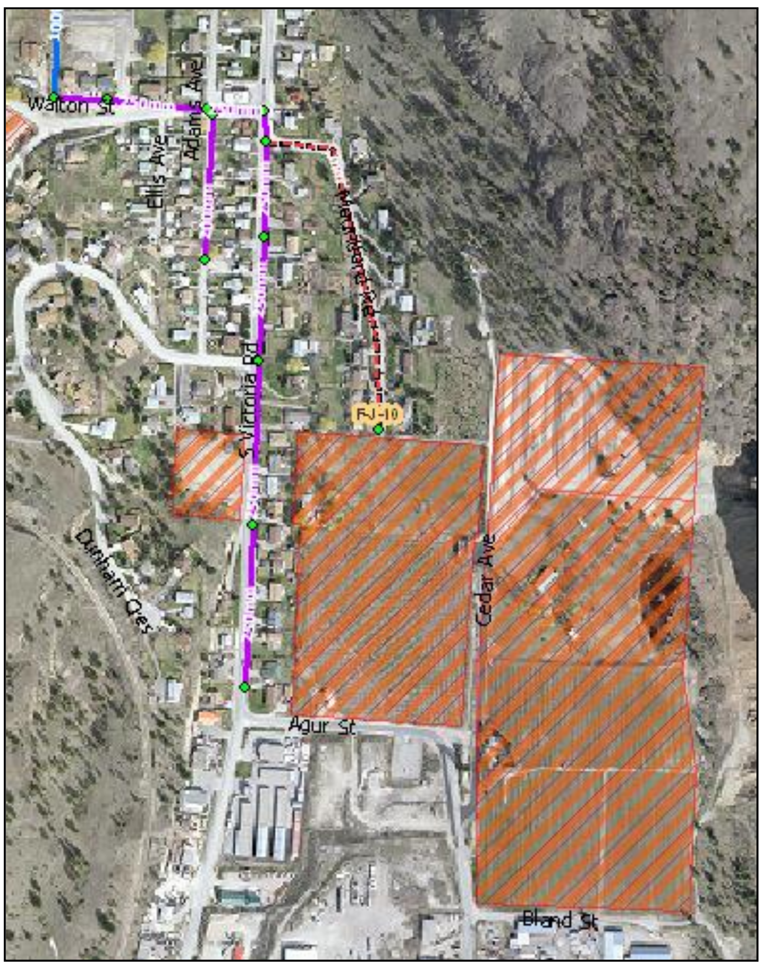
Design Flows:

	Existing	Conventional	LID	
10 year	0.035	0.205	0.100	m^3/s

Estimated Capital Costs:

Existing	Conventional	LID
$757,200	$802,300	$766,900

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
An existing storm sewer system on Victoria Road South services residential as well as some industrial development. District Staff indicate that the storm sewer is in poor condition, and is scheduled for replacement in the near future. As shown in the figure above, there is potential for significant development within the subject catchments. The replacement storm sewer, therefore, should be sized to accommodate runoff from these potential developments.

Some of the potential development area could drain to Mountford Avenue, which will be one of the major routes into the sites. How much, however, depends upon the road configuration that is ultimately constructed. To be conservative, we have routed all of the catchments which could drain to Agur Street to the intersection of Agur Street and Victoria Road. The concepts outlined in the next sections reflect this assumption.

Existing System:
Concept
For existing development, the servicing concept is to simply replace the existing storm sewer with new pipe. Victoria Road South has some asphalt curbing, but this would be upgraded to a full urban standard with concrete curb and gutters. Since the storm sewer discharges directly into a stream off Dale Meadows, some sort of stormwater quality structure, should be added to remove suspended solids and larger debris.

Proposed Works
In order to accommodate estimated 10 year peak flows under existing conditions, the following works are recommended:

- 800 m of 250 mm diameter storm sewer, including curb & gutter, catch basins, and manholes.
- One Stormceptor unit.

Implementation
These works would be included in the annual Capital Works plan.

Conventional System:
Concept
Assuming curb, gutter, and storm sewer within the potential developments, the conventional system would be comprised of storm sewers on Agur Street and Victoria Road South. The internal storm sewers would connect to those on the streets. While each development would be expected to install systems to remove suspended solids and debris from their internal storm sewer system, the District should also install a similar system to treat stormwater generated on Agur Street and Victoria Road. This is recommended since the storm sewer discharges directly into a stream channel.

Proposed Works
In order to accommodate estimated 10 year peak flows under proposed development conditions using conventional stormwater management strategies, the following works are recommended:

- 800 m of 375 mm diameter storm sewer, including curb & gutter, catch basins, and manholes.
- One Stormceptor unit.

Implementation
Since the District already intends to upgrade the drainage works on Victoria and Dale Meadows roads, these works should form part of the annual Capital Works program. However, the oversize costs should be allocated to development through an appropriate cost-recovery strategy.

LID System:
Concept
The objective in this case would be to ensure that as much rainfall as possible be introduced to the ground or stored in surface depressions on each lot. Use of perforated storm sewers and/or dry wells as manholes would reduce the amount and rate of runoff reaching the storm sewers on Agur Street and Victoria Road. Major runoff would, of course, be directed along the roadways and eventually to Prairie Creek. Since the Victoria Road corridor is already developed, a conventional storm sewer system would be used in these reaches. A structural BMP should also be installed to remove suspended solids and debris prior to discharge to Prairie Creek.

Proposed Works
The proposed works are therefore:

- 400 m of 250 mm diameter storm sewer, including curb & gutter, catch basins, and manholes (Agur to Dunham).
- 400 m of 300 mm diameter storm sewer, including curb & gutter, catch basins, and manholes (Dunham to Dale Meadows).
- One Stormceptor unit.

Implementation
See implementation section for the Conventional System.

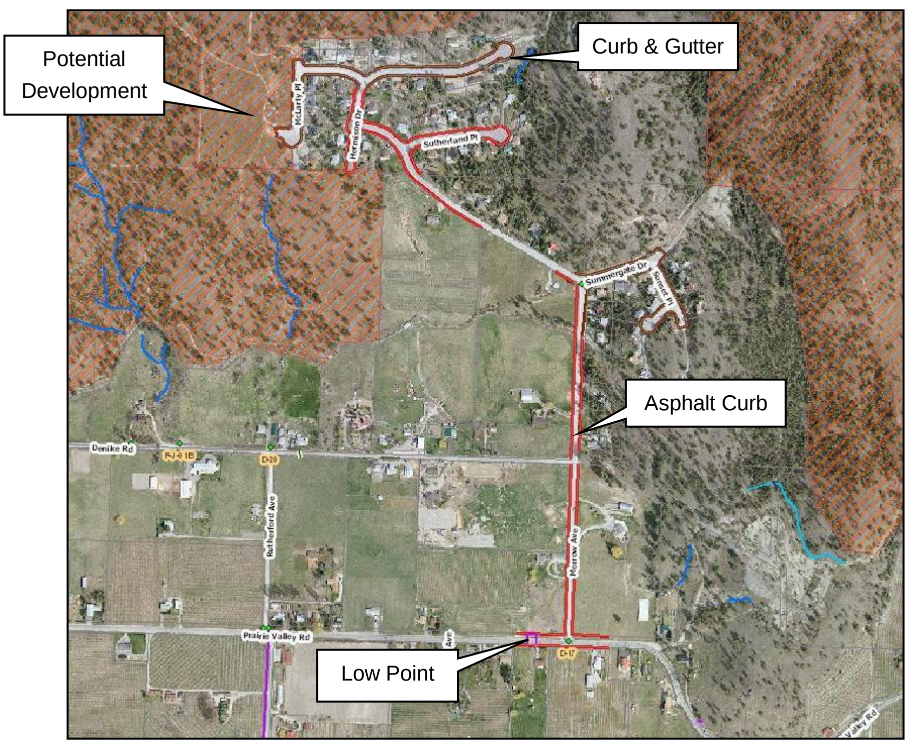
Project: PV12 **Morrow Avenue**

Priority: **2**
Trigger: Future development or Morrow Avenue upgrade.

Design Flows:	Existing	Conventional	LID	
10 year	0.038	0.155	0.065	m^3/s
100 year	0.046	0.236	0.070	m3/s

Estimated Capital Costs:	Existing	Conventional	LID
	$ 68,500	$ 1,055,300	$ 180,400

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



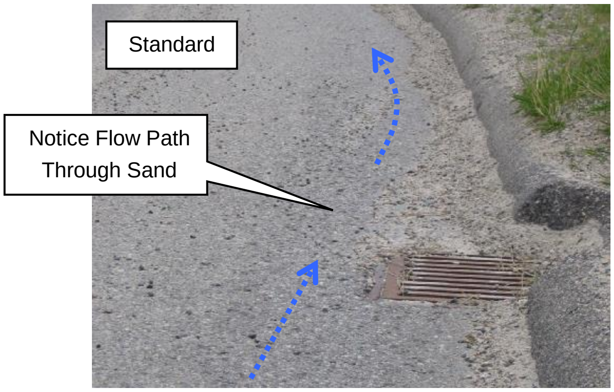
Issue:

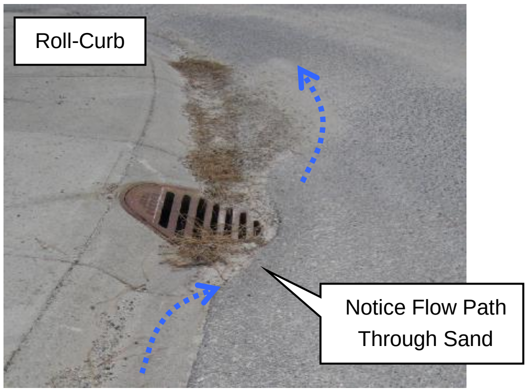
Morrow Avenue currently provides access to two developments as shown above. Most of the minor drainage is provided via curb and gutter with catch basins discharging to dry wells. Due to the steep road grades, however, runoff often overshoots the catch basins and continues to flow down Morrow Avenue. This has historically damaged the gravel shoulder when the runoff flowed off the asphalt.

In an attempt to protect the shoulder, the District has added asphalt curbing as shown. The result is a long asphalt channel which terminates on Prairie Valley Road just west of the Morrow Avenue intersection. While the runoff no longer flows over the shoulder, a significant amount of water and, in the spring time – sand, occaisionally collects at the low point indicated.

A grated inlet on the north side of the road is located at this low point. It allows surface runoff to enter a piped system which passes through the orchard on the south side of the road (see **photos 41, 43, and 44** in **Appendix F**). The size and type of pipe is unknown. At some point, the pipe discharges into an open channel which eventually drains to Prairie Creek.

District Staff have indicated that the current system is not functioning well and causes maintenance problems. The following sections outline three potential methods of addressing this issue. The "Existing System" section outlines improvements which leave most of the existing system intact. The "Conventional System" section outlines the works required to install a conventional storm sewer system, and discusses the potential impacts of doing this. The "LID System" section suggests ways of managing the runoff by diverting it to pervious areas in several locations.





Existing System:

Concept

The CB inlets within the upper subdivision (Hermiston/McLarty/Sutherland) are standard surface grates only. The lower subdivision (Summergate/Sunset) is equipped with CB inlets that match the rolled-curb profile. In many cases, neither grate captures all of the runoff generated on the road surface. This result is runoff flowing past the CBs and contributing to the flow on Morrow.

Although side-inlet CBs might enhance capture, they're less effective on steeper slopes than at low points (sump conditions). More effective improvement would be to:

- lower the grates to create a sump condition, and to
- add a second CB at key locations, which would extend the capture length.

This assumes, of course, that all runoff from the road surface flows to (and stays against) the asphalt and concrete curbs. Referring to the above images, note the sand located against the curbs – this indicates that runoff flows more in the road lane than against the curbs. Therefore, re-grading the road in some locations would ensure that runoff reaches and stays in the curb.

There is only one catch basin to service Morrow Avenue south of the two subdivisions. It is located at the Denike Street intersection. Note how the runoff misses the CB inlet and flows through the intersection. Also note that Staff has installed a significant amount of asphalt curb to keep the runoff on Morrow.

In this case, additional CBs on Morrow would be required. They should discharge to drywells located with the road right-of-way to reduce the amount of runoff that reaches Prairie Valley Road.

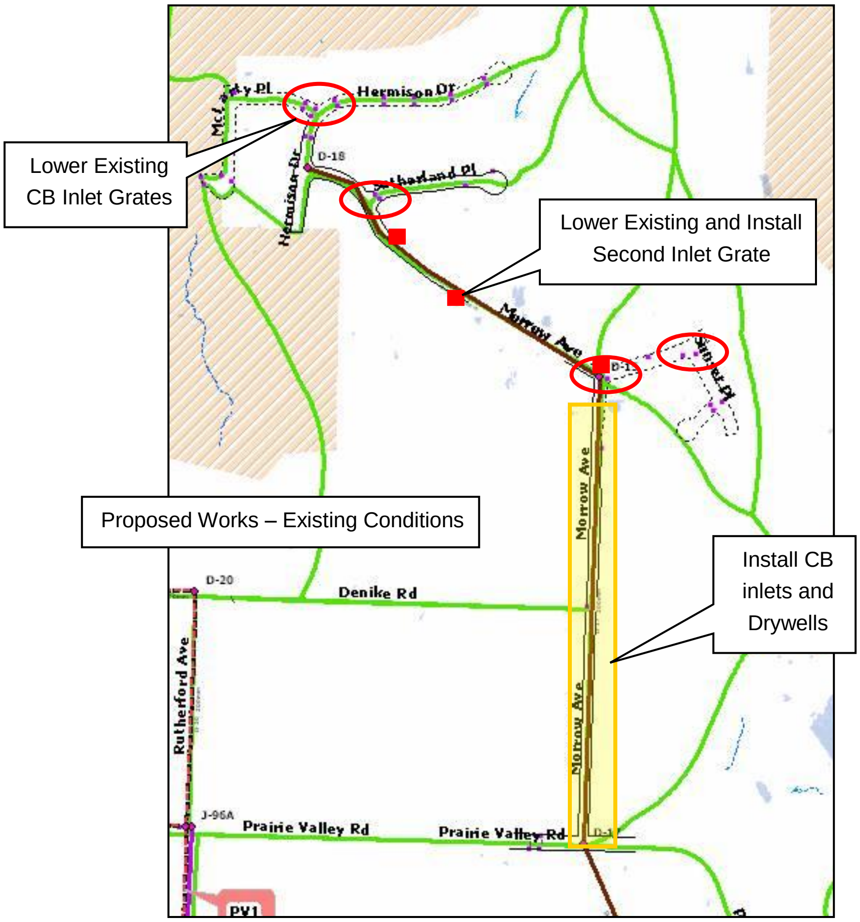
One other issue should be addressed under this section. It appears that a lot of sand is used during the winter to enhance traction on the steep, icy roads. This is a maintenance challenge with respect to the dry wells since their longevity depends upon minimizing the amount of sand that is washed into them. CBs are constructed with some sump capacity to trap suspended sediments. However, regular and frequent CB cleaning should be conducted to ensure that this capacity is maintained. As shown in the following images, the sediment loading is very high.

Proposed Works

There are approximately 30 CB inlets within the upper development, and 8 in the lower development. It is not economically feasible to modify each CB, but improved overall performance can probably be achieved by lowering select units. These would be located at each intersection. An additional inlet grate should also be added to the last CB on each side of Morrow Avenue where the curbs from the upper subdivision end. Applying the standard for manhole spacing specified in the subdivision and development control bylaw, and assuming two CB inlets per drywell, we arrive at the following estimate for the proposed works:

- Lower 12 existing CB inlets to create a sump of at least 50 mm
- Lower existing and install a second grate to 3 existing CB inlets
- Install 4 new drywells and 8 new CB inlets on Morrow Avenue

The locations of these proposed works are shown on the following figure.



Implementation

These works would be constructed as part of the annual capital works budget, and could be commenced as soon as the funds are available. They could be phased over several years if desired. In this case, the additional CBs and drywells should be installed during the first phase or phases. The existing CB inlets could be lowered in the last phase or phases.

Conventional System:

Concept

In this scenario, a storm sewer and standard curb & gutter would be installed on Morrow Avenue. It would be sized, however, to also accommodate runoff from potential development north of the existing subdivisions. The challenge with this option is what to do with the runoff once it is collected into the storm sewer and delivered to Prairie Valley Road.

As indicated in other sections of the *Master Drainage Plan*, additional direct discharge to Prairie Creek is not advisable. There is also no easement between Prairie Valley Road and the creek at the subject location. Therefore, some means of storage must be employed at the intersection of Morrow and Prairie Valley to reduce the peak flow rate to that which can be accommodated by the existing drainage system.

There are a couple of options regarding storage:

- A dry detention pond (would require purchase or long-term lease of adjacent land, or
- Underground storage (either in the road ROW, or on purchased / leased land).

While it may be less expensive to lease land for a traditional dry pond, we have assumed an underground facility within the road ROW for capital costing purposes. The required storage is based on a maximum discharge rate of 0.045 cms.

Proposed Works

- 380 m of 450 mm diameter storm sewer, including manholes, curb & gutter, and catch basins (Sunset to just south of Sutherland).
- 630 m of 525 mm diameter storm sewer, including manholes, curb & gutter, and catch basins (Prairie Valley to Sunset).
- 400 cu.m. underground storage (assume Atlantis system for costing purposes).

Implementation

These works could be installed as part of the annual capital works program. However, they could also be initiated and partially funded by future development. Note that the works extend from just south of the Sutherland Place intersection. If future development were to connect to the subject storm sewer, there would be additional offsite works that would be the full responsibility of the Developer(s).

LID System:

Concept

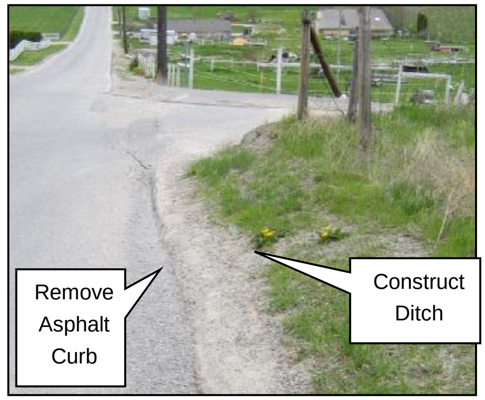
In keeping with Low Impact Development principles, the object would be to direct runoff from the road surface to the adjacent pervious land as often and as quickly as possible. This means:

- Removing the existing asphalt curb wherever the road fronts rural properties,
- Constructing ditches through cut reaches, and
- Constructing shoulders conducive to drainage where the road surface is higher than adjacent land.

The last two points require some discussion.

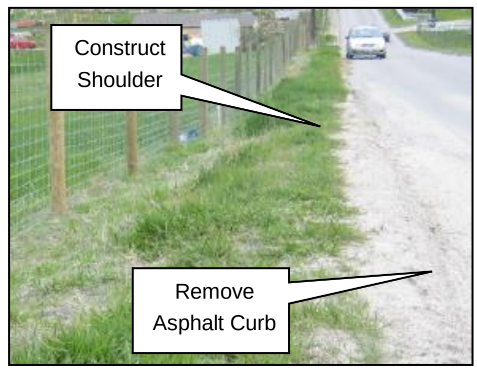
Cut Reaches

As shown on the adjacent figure, parts of Morrow Avenue pass through cut reaches, where the adjacent land is higher than the road surface. In this case, the cut bank would have to be pushed back from the road, and a ditch would be constructed to receive potential runoff.



Fill Reaches

In some areas, Morrow Avenue is higher than the adjacent land. In this case, conventional gravel should be constructed to allow runoff to flow off the asphalt and onto the adjacent pervious land.



Note that several driveway culverts will be required.

Proposed Works

- Remove and dispose of approximately 1400 m of asphalt curb,
- Construct approximately 800 m of ditch,
- Install eight 450mm culverts, and
- Construct approximately 1400 m of gravel shoulder.

Implementation

These works would be constructed as part of the annual capital works budget, and could be commenced as soon as the funds are available. They could be phased over several years if desired. In this case, the phases should start at the Prairie Valley Road intersection and progress north.

5.2 Bentley Road Basin

The Bentley Road Basin consists primarily of undeveloped and agricultural land, and covers approximately 290 hectares. It is almost bisected by Highway 97, with a significant intersection at Bentley Road.

5.2.1 Existing Drainage

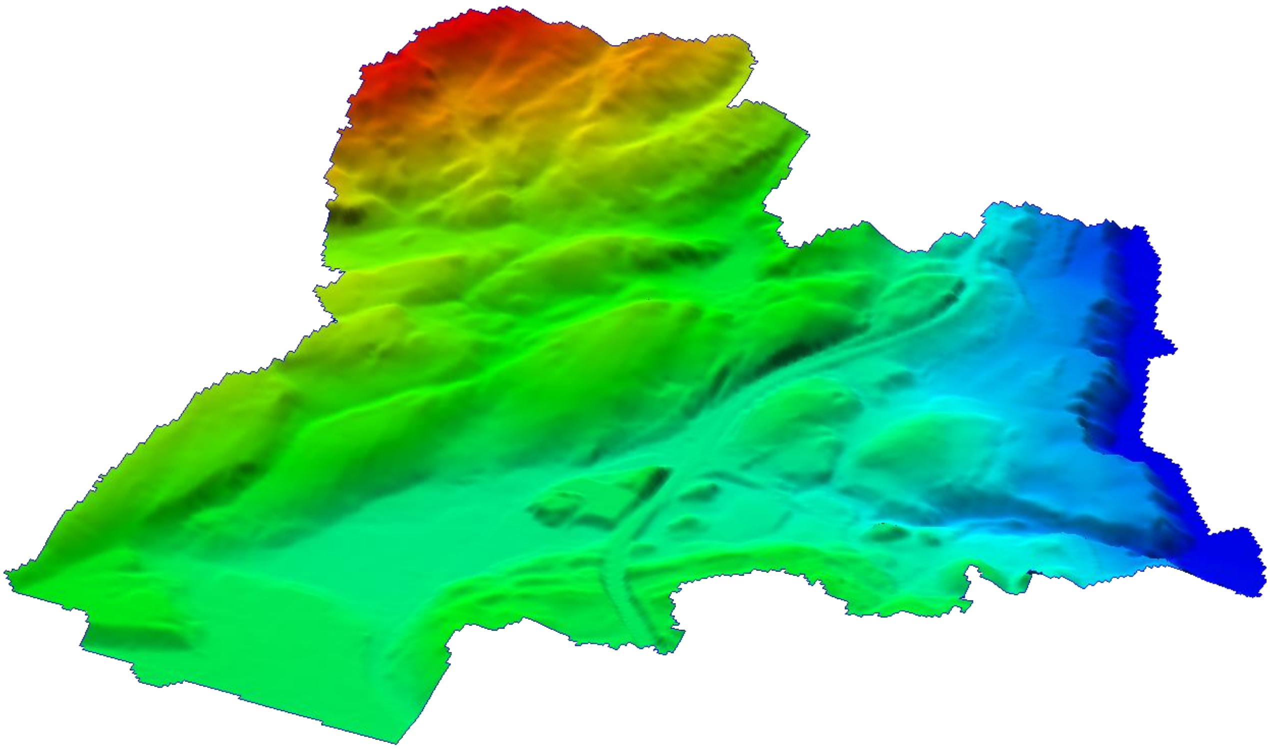
Three primary routes ultimately drain to Okanagan Lake. The most significant captures runoff from either side of Bentley Road and flows north until it enters a depression on the western side of the Bentley Road/Highway 97 intersection. Here it enters a storm sewer system which crosses the highway and is released into a natural ravine. After passing through a small wetland on private property, runoff drains to Okanagan Lake via a 1,600mm CSP culvert at the west end of N. Lakeshore Dr.

The northern most route drains to a pond on Rattlesnake Mountain which intercepts and attenuates flows. Ultimately, runoff flows along the highway to a 500mm culvert across the highway, and down a natural ravine to the lake. Runoff from agricultural land on the eastern side of the highway, north of the primary ravine, follows the natural topography to the lake. Flooding along this route on McDougald Road has been reported following heavy storms.

The road cross sections are typically rural in nature allowing drainage to infiltrate on the shoulders or within ditches. The natural rocky eastern slopes of Rattlesnake Mountain cover the majority of the western half of the basin. Sparsely vegetated with evergreens, there are no records to date of significant surface runoff reaching the base near Bentley Road. This indicates that the overlaying topsoil on the slopes has sufficient capacity to capture and store most rainfall.

Sumac Ridge golf course and residential development borders the basin to the south east. Historically, runoff from the residential area have crossed Logie Road on its way to the large ravine.

Figure 5.2.1
Topography of Bentley Road Basin. Blue to red represents increasing elevation.



5.2.2 Land Use

<u>Existing</u>

Referring to **Figure 5.2-2**, the entire north western portion of the Bentley Road basin is sparsely vegetated with tuft grass and coniferous trees. Except for a pocket of industrial development located at the southwest corner of the Bentley Road / Highway 97 intersection, the rest of the basin is comprised mostly of agricultural land with small amounts of rural and low density residential development.

<u>Future</u>

The western half of the catchment contains most of the residential development projected on Rattlesnake Mountain. One other small development within the southern part of the basin is also identified, but it is already being constructed. These developments are located upstream of the piped major drainage route at the Bentley Road / Highway 97 intersection.

5.2.3 Infiltration Potential

Surficial Soils

Referring to **Figure 5.2-3**, and with the exception of the exposed rock on Rattlesnake Mountain, the Bentley Road Basin is comprised of soils which generally drain rapidly.

Groundwater Conditions

Little information is available regarding groundwater conditions in this basin. Surface flows and a wetland within the primary ravine downstream of the Bentley Road / Highway 97 intersection were noted in the field. It is possible that these flows are fed by seepage from infiltrated rain and irrigation water flowing just under the soil surface.

Conclusion

It appears that in general, stormwater within this basin could be disposed to ground through infiltration systems. This should be confirmed with site-specific geotechnical studies as part of any future development approval process.

5.2.4 Analysis

The basin presents several stormwater management challenges:

- Steep slopes on Rattlesnake Mountain have the potential to create large volumes of runoff during high intensity storms.
- The storm sewer system at the Bentley Road/Highway 97 intersection services the majority of the western side of the highway with a fixed maximum capacity.
- Existing drainage infrastructure discharges into a ravine consisting of silty soils which can be susceptible to erosion and lead to blockages in downstream culverts.
- Future development on the eastern slopes of Rattlesnake Mountain have the potential to add significant runoff volumes to the existing storm sewer system. They also have the potential to impact private properties along the base of the mountain.

Analyses indicate, however that:

- Under existing conditions, the large proportion of agricultural and undeveloped areas within the basin provides good infiltration, with sufficient storage capacity to capture most rainfall. Therefore, no existing hydraulic deficiencies were noted.
- Under LID conditions, the extra runoff generated within the proposed development on Rattlesnake Mountain quickly infiltrated as it flowed overland and through the downstream routes.

- Under Conventional conditions, the collected runoff generated within the proposed development on Rattlesnake Mountain was significantly higher than what currently exists. The hydraulic capacity of the piped systems, however, was sufficient to accommodate these higher flows.

Note that even though the piped systems have sufficient capacity to accommodate the projected peak flow from a conventional drainage system in the proposed development on Rattlesnake Mountain, the velocities in the natural ravine would be high enough to cause damage through erosion. It is therefore recommended that on-site attenuation be required as part of the development process as per the unit discharge rates outlined in **Section 4.4**.

5.2.5 Projects

Only two projects were identified for this basin – both would be implemented to address existing deficiencies. They are recommended to improve major drainage route definition and connectivity, and can be located on **Figure 5.2-1**. Detailed descriptions of each project are provided within the remainder of this section. Refer to **Figure 5.2-P1** for additional context.

Project: BR-01 Bentley Road: Sanborn to Crisante

Priority: **3**

Trigger: Bentley Road upgrade, recurring flooding issues or annual capital expenditure

100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1558	0.025	-	-	m^3/s
1559	0.025	-	-	m^3/s
1560	0.036	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$47,100	$47,100	$47,100

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:
Risk of runoff crossing Bentley Road from the west at a variety of locations and entering a development on the east.

Concept:
Define major drainage route to transport runoff to the Bentley Road storm sewer system.

Proposed Works:

Existing System:
Construct ditching and install driveway culverts along the east side of Bentley Road from the Sanborn Street intersection. A culvert across Bentley Place will also be required.

LID System:
Upstream development is not anticipated to impact the proposed works under the existing scenario.

Conventional System:
Upstream development is not anticipated to impact the proposed works under the existing scenario.

Implementation

Works should be constructed when one of the following occurs:

- Bentley Road is upgraded, or
- Runoff crossing Bentley Road becomes an issue

Project: BR-02 Logie Road: North of Golf Course

Priority: **3**

Trigger: Logie Road upgrade, recurring flooding issues or annual capital expenditure

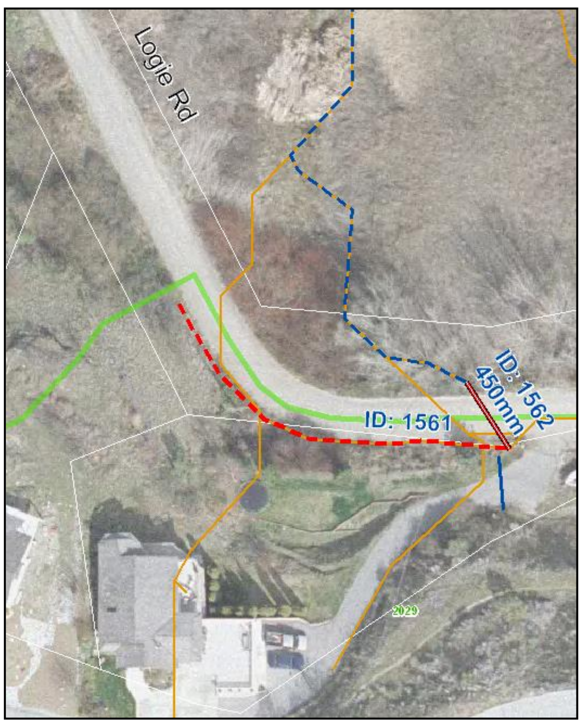
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1561	0.001	-	-	m^3/s
1562	0.010	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$24,300	$24,300	$24,300

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:

Flow has been recorded crossing Logie Road at the base of a private driveway during heavy storms causing erosion.

Concept:
Define major drainage route to transport runoff across Logie Road.

Proposed Works:

Existing System:
Construct ditching along the south of Logie Road and a culvert at the base of the driveway directing flow north into the ravine.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Logie Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

5.3 Lakeshore Basin

The Lakeshore Basin covers approximately 209 hectares. It is not a true drainage basin, but is rather an arbitrarily defined area which drains to Okanagan Lake via numerous routes. It covers the area between the Bentley Road Basin and Eneas Creek outlets to the lake.

5.3.1 Existing Drainage

There are no perennial streams present in the basin, however, there are numerous ephemeral streams which exhibit flow during heavy rainfall or snow melt conditions. Drainage throughout the basin is provided by natural ravines and gullies created during glacial melt. The basin is relatively flat with numerous hills and depressions. The eastern boundary is characterized by steep silt bluff dropping to Lakeshore Road, and ultimately, to Okanagan Lake. This can be seen from the topography shown in **Figure 5.3.1**.

Figure 5.3.1
Topography of Lakeshore Basin. Blue to Yellow represents increasing elevation.

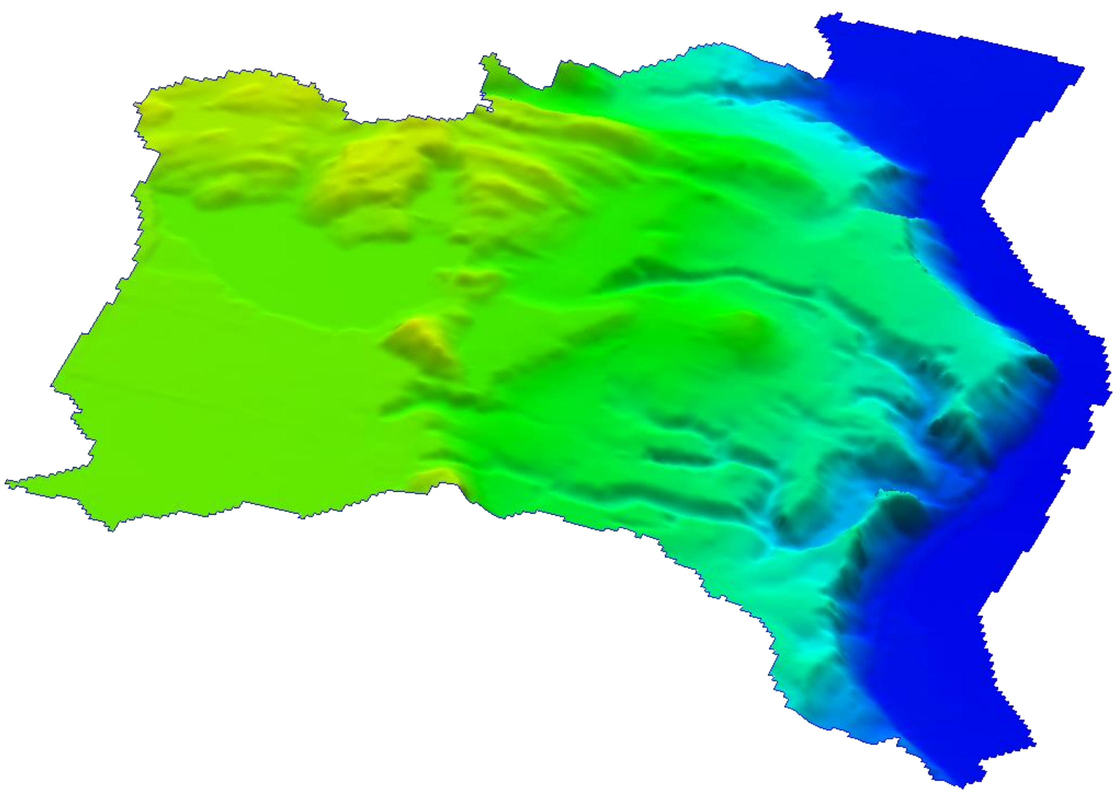
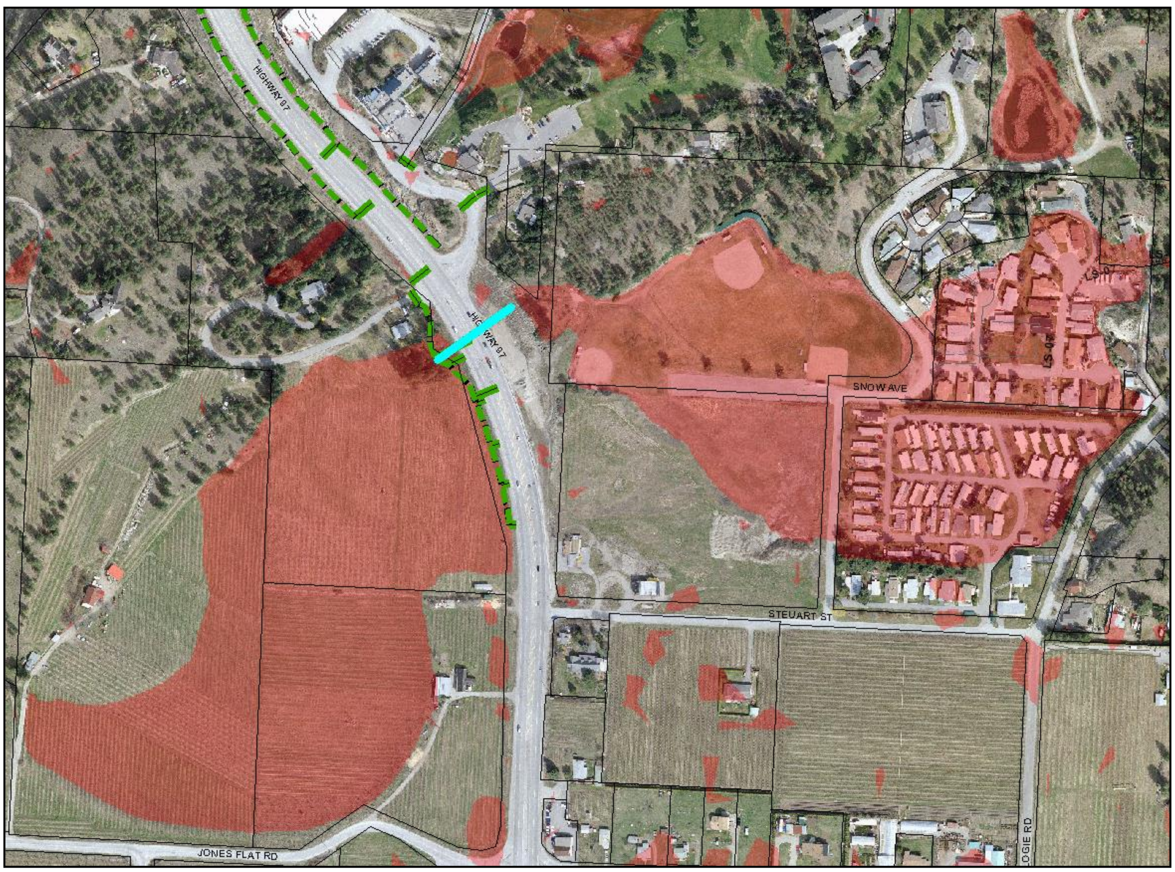


Figure 5.3.2 shows two depressions which cover a large area located on both sides of Highway 97 just north of Jones Flat Road. They are connected by a 600mm diameter culvert (highlighted). The depression on the eastern side of the highway contains baseball diamonds, a mobile home park, and a residential strata development. Dry wells are currently used to dispose of surface runoff, and although there has been no flooding issues reported to date, a risk of flooding and property damage exists under extreme rainfall events since there is no major drainage route from this area.

A small detention pond located to the north of the strata development also has no established emergency drainage route. In the event of a failure, it would drain directly south into the depression and flood properties.

Figure 5.3.2 - Aerial map of the east portion of Lakeshore Basin showing the two large depressions either side of Highway 97 connected by a 600mm culvert (light blue).



In general, roads have rural cross sections, and drainage infrastructure is limited to culverts. Drywells are used within some of the residential developments.

With the majority of the basin located on a plateau above the silt bluffs, drainage routes which are not tributary to the larger ravines, pass directly over the bluffs. In most cases, this has not caused problems because the surface soils have sufficient capacity to retain most rainfall. On July 19th, 2007, however, a long, intense storm did generate sufficient runoff from a recently planted vineyard to cause flooding and a small debris flow through three properties on Lakeshore Road. This event emphasizes the importance of ensuring that any disturbances to established, vegetated soils also incorporate effective stormwater management and erosion prevention practices.

5.3.2 Land Use

Existing

As shown in **Figure 5.3-2**, agriculture is widespread throughout the basin. There is a small pocket of light industrial development near Logie and Jones Flat Roads, and a low density residential golf course development situated along the north-west basin boundary. Two pockets of low-density residential development are located at either end of N. Lakeshore Drive. The rest of basin is comprised of sparse rural residential properties.

Future

Currently, no future development has been identified within the Lakeshore Basin.

5.3.3 Infiltration Potential

Surficial Soils

Referring to **Figure 5.3-3**, most of the Lakeshore Basin is comprised of soils which are well to rapidly drained. The exception is the band of silt bluffs along the eastern boundary of the basin.

Groundwater Conditions

In general, groundwater seems to remain well below the surface. There is, however a small base flow within the ravine which extends from the intersection of Logie and Fosbery Roads to the lake. This would suggest that shallow groundwater does move toward the ravine where it surfaces.

Conclusion

Based on the above information, use of infiltration systems to dispose of storm runoff should be feasible. A detailed site investigation should, however, be conducted by a qualified hydro-geologist to confirm local site suitability.

5.3.4 Analysis

The basin presents several stormwater management challenges:

- Drainage from the strata community and mobile home park located within a large depression is limited, placing the area at risk of flooding under heavy runoff events.
- A significant number of natural ravines spread throughout the catchment. Culverts and ditches need to be located correctly to ensure runoff is directed downstream effectively, avoiding damage to roads and property.
- Stripping and grubbing of agricultural land can increase runoff volume and rates significantly. This can lead to erosion and transport of sediment onto private properties and into the lake.

Analysis indicates that:

- Under existing conditions, the large agricultural and rural development within the basin provides good infiltration, with sufficient storage capacity to capture most rainfall. Therefore, no existing hydraulic deficiencies were noted.
- The relatively low-density of residential strata development within the depression south of the golf course ensures that the generated runoff is minimal. As long as the existing dry wells continue to function as designed, the associated flood risks should remain low.
- The rural roads may be subject to surface runoff crossing from one side to the other at low points because of current topography. This is addressed by the recommended projects outlined in the following section.

5.3.5 Projects

Twelve Priority 3 projects were recommended for this basin to improve major drainage route definition and connectivity. All of them are allocated to address existing deficiencies, and can be located on **Figure 5.3-1**. Detailed descriptions of each project are provided within the remainder of this section. Refer to **Figures 5.3-P1** to **5.3-P3** for additional context.

Project: LS-02 Whitfield Road: East of Slater Road

Priority: 3

Trigger: Whitfield Road upgrade, recurring flooding issues or annual capital expenditure

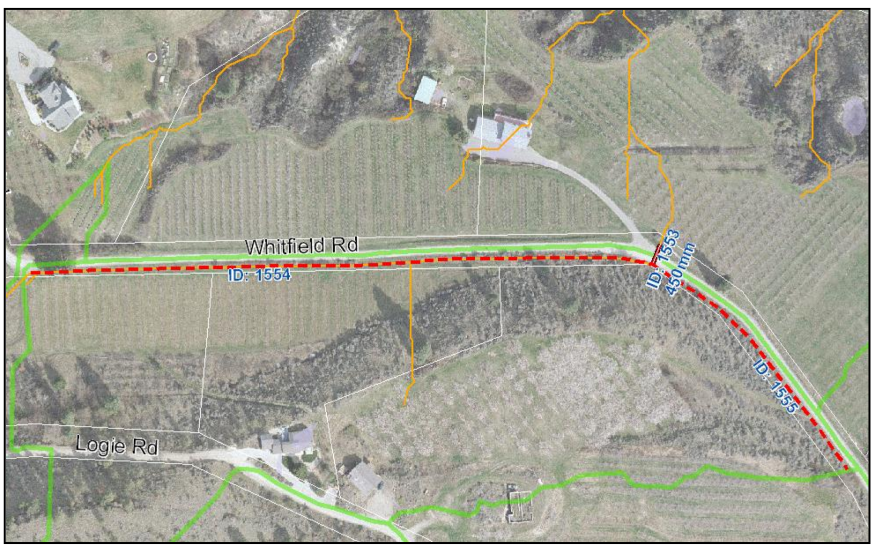
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1553	0.001	-	-	m^3/s
1554	0.001	-	-	m^3/s
1555	0.001	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$29,600	$29,600	$29,600

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:

Poorly defined major drainage along Whitfield Road increases the risk of runoff crossing road and causing erosion and/or flooding.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Construct ditching along south side of Whitfield Road with a culvert at the low point.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Whitfield Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: LS-03 Whitfield Road: Between Slater and Huddleston

Priority: **3**

Trigger: Whitfield Road upgrade, recurring flooding issues or annual capital expenditure.

100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1550	0.001	-	-	m^3/s
1551	0.004	-	-	m^3/s
1552	0.001	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$25,600	$25,600	$25,600

Note: *Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.*

Issue:
Poorly defined major drainage along Whitfield Road increases the risk of runoff crossing road and causing erosion and/or flooding.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Construct ditching along west side of Whitfield Road with a culvert at the low point.

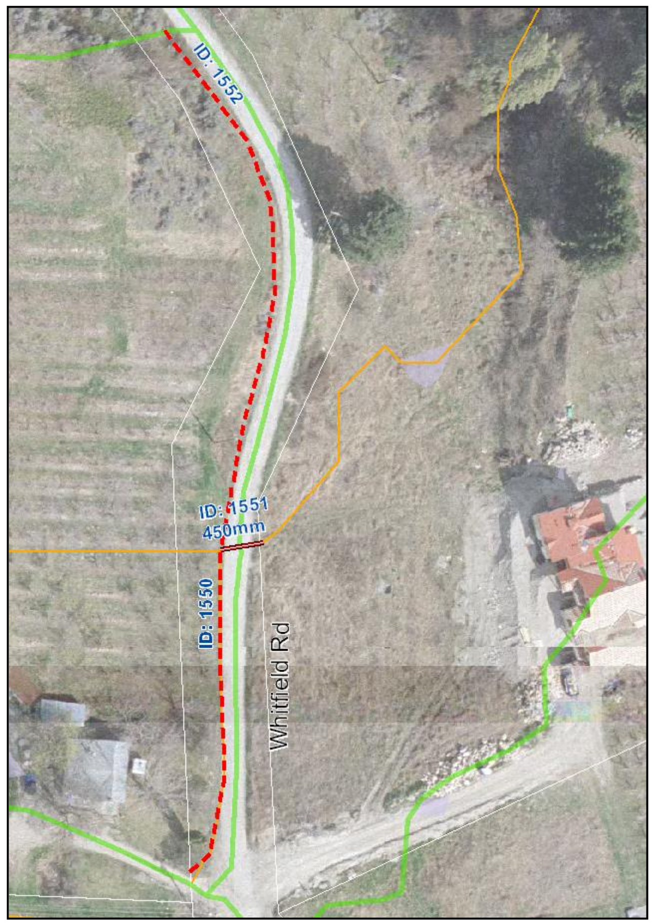
LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:

Works should be constructed when one of the following occurs:

- Whitfield Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget



Project: LS-04 Whitfield Road: North of Huddleston Road

Priority: **3**

Trigger: Whitfield Road upgrade, recurring flooding issues or annual capital expenditure.

100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1540	0.001	-	-	m^3/s
1541	0.001	-	-	m^3/s
1542	0.005	-	-	m^3/s
1543	0.003	-	-	m^3/s
1549	0.002	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$64,800	$64,800	$64,800

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:
Existing culvert is wood stave, and requires an upgrade. In addition, poorly defined major drainage along Whitfield Road increases the risk of runoff crossing road and causing erosion and/or flooding.

Concept:
Replace the existing culvert and improve major drainage route definition.

Proposed Works:

Existing System:
Install a culvert across the west side of the Huddleston Road intersection to overcome topography. Construct ditching along the west side of Whitfield Road and upgrade the existing culvert.

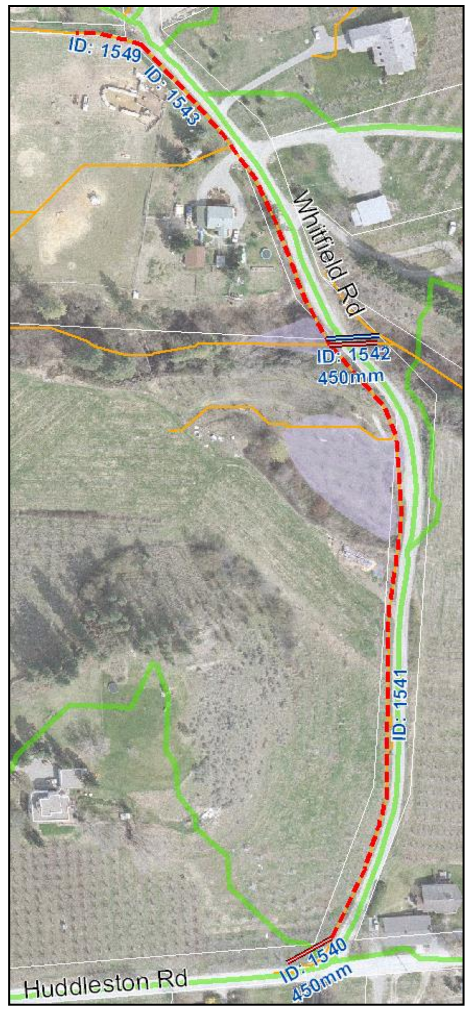
LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:

Works should be constructed when one of the following occurs:

- Whitfield Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget



Project: LS-05 Logie Road: North of Fosbery Road

Priority: **3**

Trigger: Logie Road upgrade, recurring flooding issues or annual capital expenditure.

100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1544	0.003	-	-	m^3/s
1545	0.002	-	-	m^3/s
1546	0.001	-	-	m^3/s
1547	0.001	-	-	m^3/s
1548	0.001	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$67,900	$67,900	$67,900

Note: *Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.*

Issue:
Poorly defined major drainage along Logie Road increases the risk of runoff crossing road and causing erosion and/or flooding.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Installation of ditching along the west side of Logie Road with culverts discharging to the east at the low points.

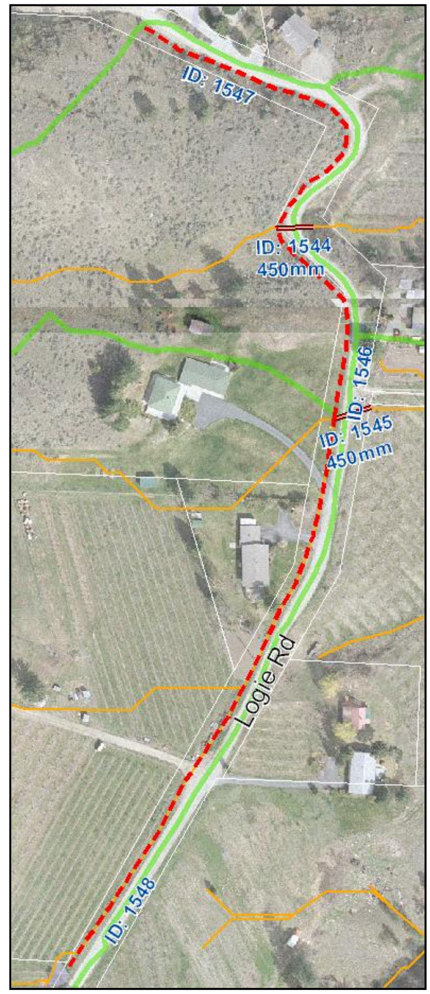
LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:

Works should be constructed when one of the following occurs:

- Logie Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget



Project: LS-06 Logie Road and Fosbery Road

Priority: 3

Trigger: Logie Road or Fosbery Road upgrade, recurring flooding issues or annual capital expenditure.

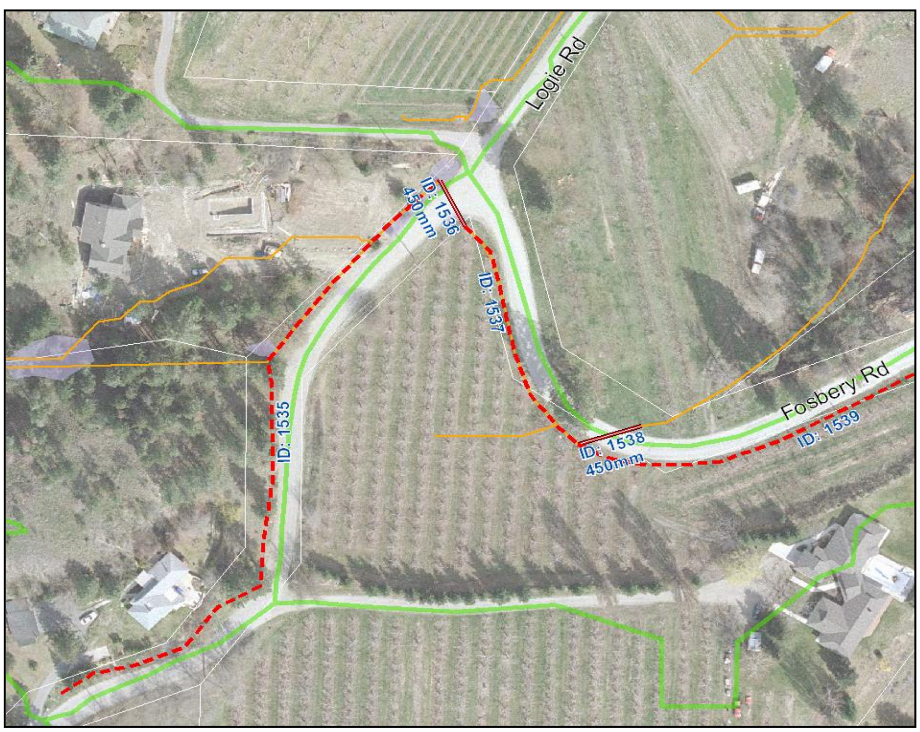
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1535	0.025	-	-	m^3/s
1536	0.029	-	-	m^3/s
1537	0.029	-	-	m^3/s
1538	0.032	-	-	m^3/s
1539	0.001	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$70,000	$70,000	$70,000

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
Poorly defined major drainage between Whitfield Road and Fosbery Road increases the risk of runoff crossing road and causing erosion and/or flooding.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Construct ditching along the west side of Logie Road and along the south side of Fosbery Road and connect them with a culvert. Install a culvert on Fosbery Road to direct flows to the ravine on the east at the low point.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Logie Road or Fosbery Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: LS-08 **Fosbery Road and Kean Street**

Priority: **3**

Trigger: Fosbery Road or Kean Street upgrade, recurring flooding issues or annual capital expenditure.

100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1529	0.017	-	-	m^3/s
1530	0.021	-	-	m^3/s
1531	0.001	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$95,100	$95,100	$95,100

Note: *Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.*

Issue:
Poorly defined major drainage along Fosbery Road and Kean Street increases the risk of runoff crossing road and causing erosion and/or flooding.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Construct ditching along the west side of Fosbery Road and the north side of Kean Street. Install a culvert installed immediately prior to the intersection.

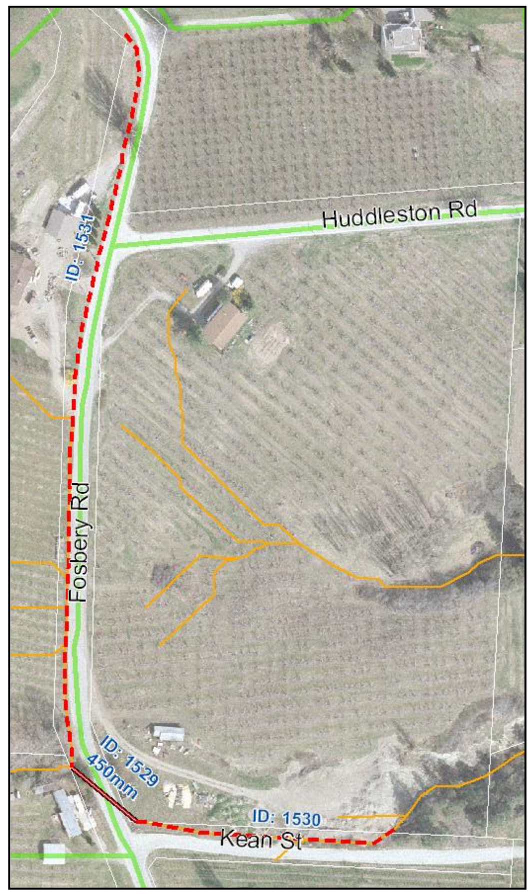
LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:

Works should be constructed when one of the following occurs:

- Fosbery Road or Kean Street is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget



Project: LS-09 North Lakeshore Drive: Downstream of Kean Street

Priority: **3**

Trigger: North Lakeshore Drive upgrade, recurring flooding issues, or annual capital expenditure.

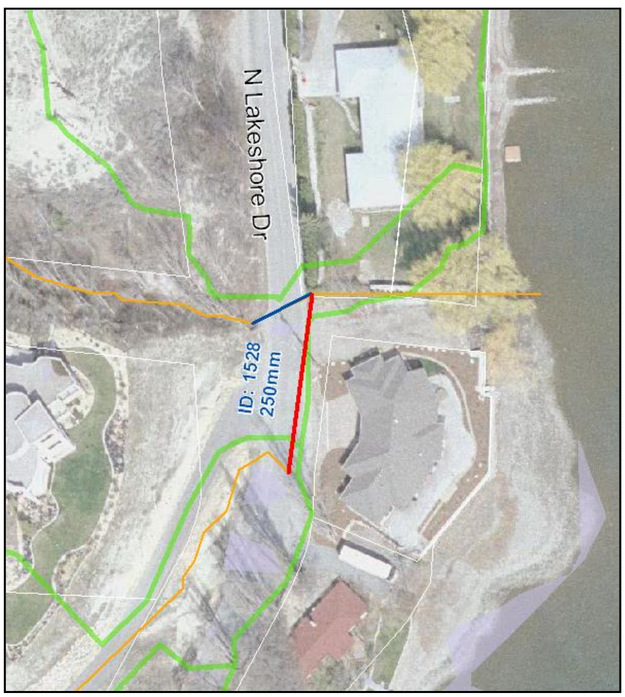
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1528	0.002	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$23,400	$23,400	$23,400

Note: *Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.*



Issue:

Poorly defined major drainage along North Lakeshore Drive increases the risk of runoff crossing road and causing erosion and/or flooding.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Install piping and a set of side-inlet catch basins along the east side of North Lakeshore Drive. This will also require some curbing and some re-grading to form sumps to capture surface runoff.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- North Lakeshore Drive is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: LS-10 Fosbery Road: Kean to Switchback

Priority: 3

Trigger: Fosbery Road upgrade, recurring flooding issues or annual capital expenditure.

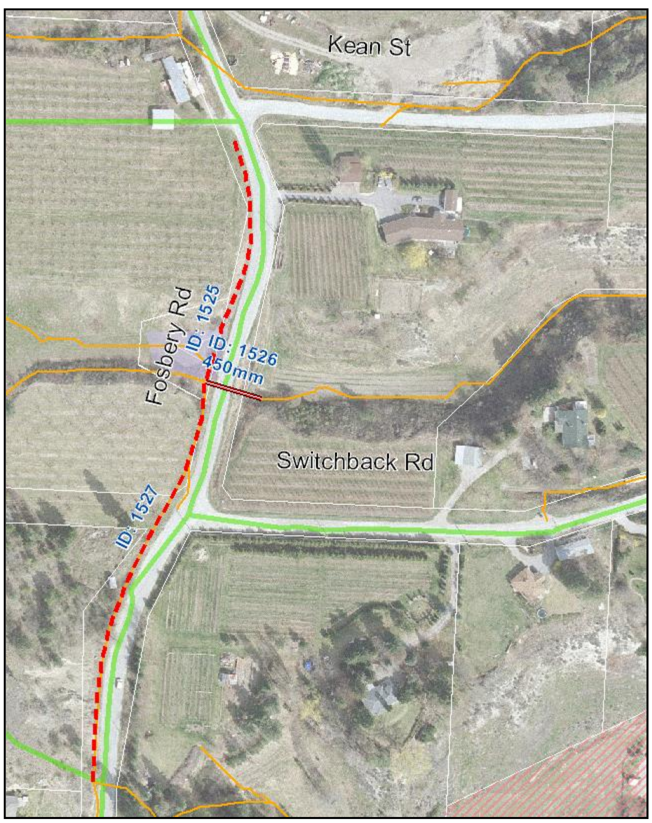
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1525	0.001	-	-	m^3/s
1526	0.014	-	-	m^3/s
1527	0.008	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$44,700	$44,700	$44,700

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
The natural ravine west of Fosbery Road has been filled-in for agricultural purposes. During the July, 2007 storm, runoff from the still-maturing vineyard crossed the road, severely eroding the east shoulder and fill slope. No existing culvert was noted.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Construct ditching along the west side of Fosbery Road and install a culvert discharging to the east at the low point.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Fosbery Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: LS-11 Jones Flat Road: East of Industrial Avenue

Priority: **3**

Trigger: Jones Flat Road or Industrial Avenue upgrade, recurring flooding issues or annual capital expenditure.

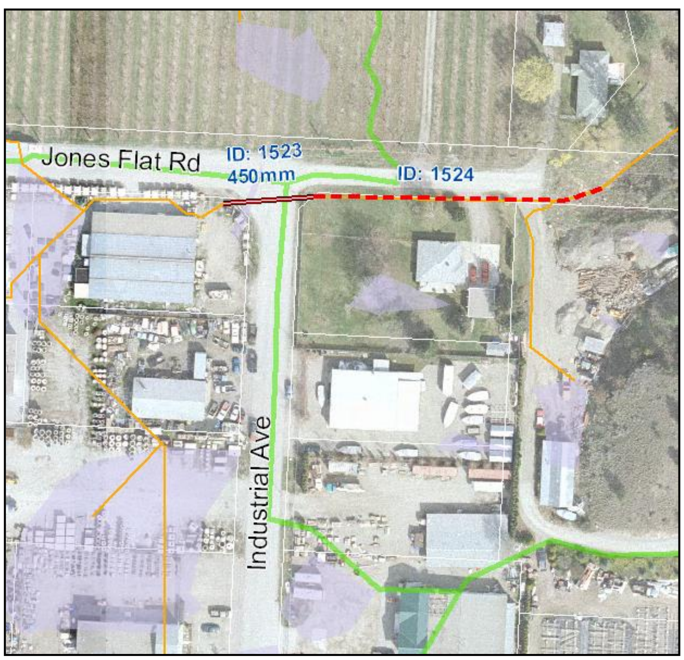
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1523	0.007	-	-	m^3/s
1524	0.008	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$39,700	$39,700	$39,700

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:

Poorly defined major drainage at the intersection of Jones Flat Road and Industrial Avenue increases the risk of runoff crossing road and causing erosion and/or flooding.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Install a culvert across Industrial Avenue with ditching to the east to direct flows to the existing ravine. Install driveway culverts as required.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Jones Flat Road or Industrial Avenue is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: LS-12 North Lakeshore Drive: North of Peach Orchard Road

Priority: **3**

Trigger: North Lakeshore Drive upgrade, recurring flooding issues, or annual capital expenditure.

100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1521	0.019	-	-	m^3/s
1522	0.018	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$43,600	$43,600	$43,600

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:
Poorly defined major drainage along North Lakeshore Drive increases the risk of runoff crossing road and causing erosion and/or flooding. This was confirmed during the July, 2007 storm when runoff from a newly planted vineyard cascaded over the bluffs, crossed the road, and spread through three properties before reaching Okangan Lake.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Construct ditching along the west side of North Lakeshore Drive and install a culvert to Okanagan Lake at the low point.

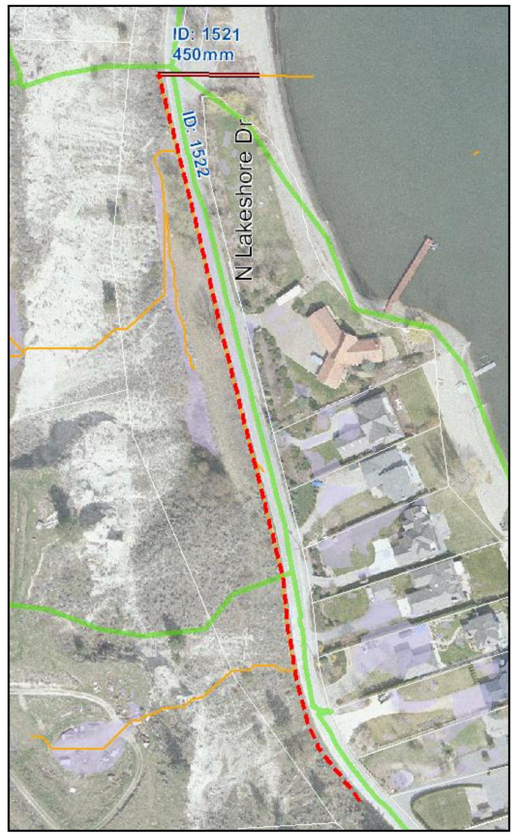
LID System:
No upstream development is anticipated.

Conventional System:
No upstream development is anticipated.

Implementation:

Works should be constructed when one of the following occurs:

- North Lakeshore Drive is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget



5.4 Eneas Creek Basin

Eneas Creek is a perennial stream flowing from Garnet Lake under controlled conditions. Although it is the largest drainage basin in Summerland, approximately 2770 hectares, most of it drains to Garnet Lake. For the purposes of this Master Drainage Plan, The basin was truncated approximately 500m south of the intersection of Garnet Valley Road and Gallagher Street because:

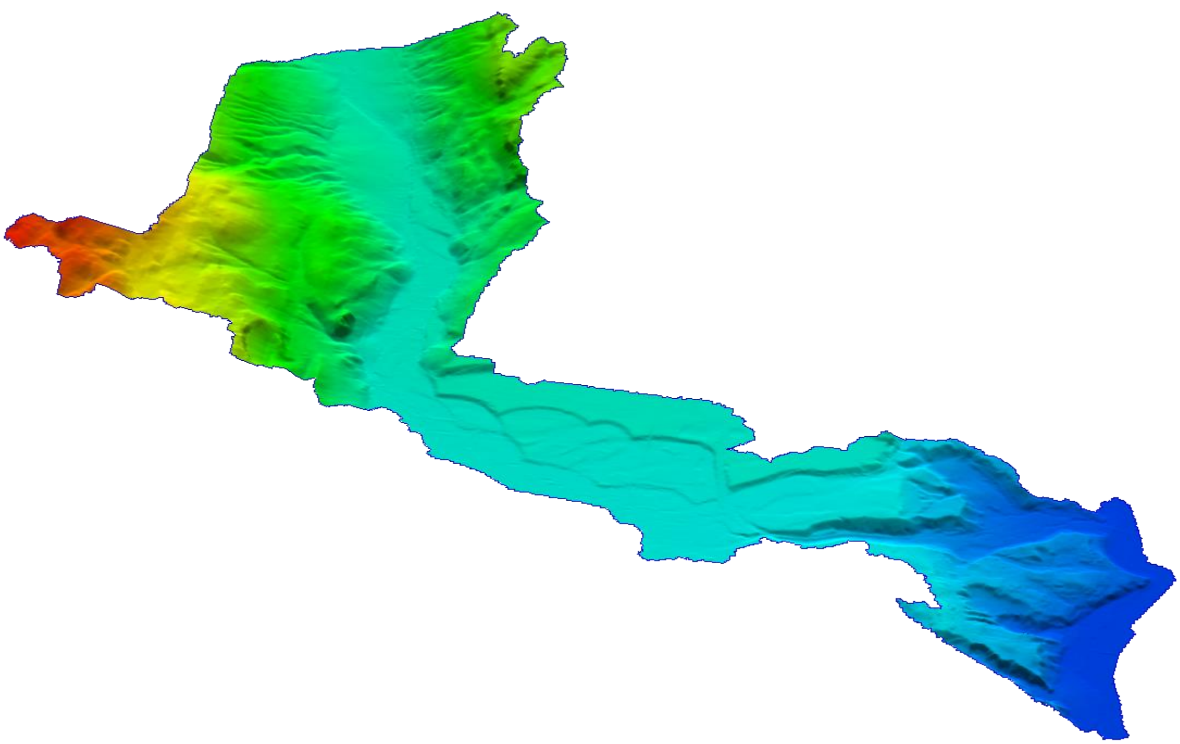
- upstream of this location, no future development is planned,
- flows are controlled, and
- rainfall has little impact on the stream flow rates.

The analyzed basin covers approximately 756 ha. It also includes the area which drains to the lake between the Eneas Creek and Prairie Creek outlets.

5.4.1 Existing Drainage

Eneas Creek is the predominant drainage system within the basin flowing from Garnet Lake to Okanagan Lake. Garnet Lake is used to provide 8-10% of the District of Summerland's total water requirements in the summer, and flow into Eneas Creek is dependent upon the level desired within Garnet Lake. **Figure 5.4.1** shows the topography of the catchment and the location of Eneas Creek.

Figure 5.4.1
Topography of Eneas Creek Basin. Blue to red represents increasing elevation.



Due to downstream flood concerns during the freshet, and because full storage prior to the start of the irrigation season in April is desired, the level in Garnet Lake is reduced in the fall once irrigation has ended. This is achieved by opening a 75mm fish gate which normally remains open through most of the winter. Early in January, it may be necessary to open the main dam valve (450mm slide gate) in order to further reduce the lake level. The target level is generally the 8m level on the reservoir staff gauge since this has historically allowed Garnett Lake to reach full pool before the start of the irrigation season without significant discharges over the dam spillway during freshet. During the winter season, ice sometimes builds up in Eneas Creek, which can lead to localized flooding. Therefore, discharge rates are carefully managed.

Drainage within the Eneas Creek basin consists primarily of constructed open channels and culverts. Most of the exiting culvert are located either on Eneas Creek or along the highway. The creek channel becomes constricted by existing development just west of Garnet Avenue, and remains so until it passes under Highway 97. Local residents have seen Eneas Creek overflow the banks of these constructed channels, indicating that the stream has previously exceeded its maximum capacity. On the east side of the highway, the creek flows within a deep ravine until it enters Okanagan Lake. While it passes through many private properties within this lower reach, the channel is relatively well defined, stable due to vegetation, and serviced by relatively large-diameter culverts.

There is a significant amount of storm sewer infrastructure within the area east of the highway, bordered by Eneas and Prairie Creeks. This consists of 200mm and 250mm PVC pipe, and were presumably constructed to transport runoff collected in depressions and flat areas to Okanagan Lake via four discharge locations.

Most of the roads within the Eneas Creek basin have rural cross sections. Asphalt and concrete curbs have been utilized in select locations, however, either to:

- Manage flows on steeper road sections, or to
- Service development.

5.4.2 Land Use

Existing

The upper reaches of Eneas Creek Basin northwest of Blair Street are predominantly larger agricultural lots within the ALR, as well as natural landscape. Pockets of low and medium density residential development are located on the west side of Highway 97 and along the lake shore and hillside overlooking Okanagan Lake. The east side of the highway also includes a significant amount of agricultural land. This can be seen in **Figure 5.4-2**. Pockets of light industrial development - primarily greenhouses - are also within this basin.

Future

A residential development is proposed for the western slopes of Rattlesnake Mountain, and another phase of the multi-family development on N. Victoria Road and Turner St. is yet to be constructed. A smaller 15 lot development on Switchback Road is also proposed.

5.4.3 Infiltration Potential

Surficial Soils

The drainage characteristics of the soils bordering Eneas Creek west of the highway are classified as "moderately poor". East of the highway, however, soil drainage within the stream channel improves to "moderately well". However, except for the silt bluffs, the rest of the basin appears to contain soils classified as having "rapid" drainage characteristics.

Groundwater Conditions

The only location where groundwater seeps to the surface is within the lower 700 m of the Eneas Creek channel. This includes tributary spring fed streams along Switchback Road, Kato Street, and Blewett Road.

Conclusion

Conditions for discharging stormwater to ground are probably suitable for the Rattlesnake Mountain and N. Victoria Road developments. However, this does not appear to be a feasible option for the development on Switchback Road. In all cases, however, a detailed site investigation should be conducted by a qualified hydro-geologist to confirm local site suitability whenever infiltration systems are proposed.

5.4.4 Analysis

The basin presents several stormwater management challenges:

- Contains a stream with varying seasonal base flow
- A large portion of the stream is confined to a constructed channel within its lower reaches, and passes through many culverts. This establishing fixed a fixed hydraulic capacity.
- The lower reaches of Eneas Creek have steeper slopes, so the potential for erosion increases significantly as peak flows increase.

Analysis indicates that:

- Under existing conditions, Eneas Creek is influenced very little by rainfall events. This is due to the capacity of the surface soil layer within the agricultural and natural landscape areas to capture and infiltrate rainfall.
- Historical flooding along Eneas Creek may be due to high release rates from Garnet Lake, and/or ice blockages within the stream.

- Under LID development conditions, the extra runoff generated within the proposed development on Rattlesnake Mountain is anticipated to quickly infiltrate as it flows overland and through the downstream routes.
- Under Conventional development conditions, the collected runoff generated within the proposed development on Rattlesnake Mountain would be significantly higher than what currently exists. While the Eneas Creek channel and culverts may have sufficient hydraulic capacity to accommodate these projected peak flow rates, the associated velocity increases and flow durations would cause significant erosion. This is especially true within the lower, steeper reaches east of Highway 97. On-site attenuation for flows up to the 100 year conditions should be required as part of the development process as per the unit discharge rates outlined in **Section 4.4**.
- For the other future development sites identified within the Eneas Creek basin, on-site attenuation for up to the 10 year conditions should be sufficient.

5.4.5 Projects

Fifteen projects were identified for this basin – one Priority 1, six Priority 2, and eight Priority 3. The Priority 1 project is EC-06, and is comprised of installing a piped drainage route from the cul-de-sac on Bristow Road to Eneas Creek. This project, along with three of the Priority 2 projects, address drainage system failures which occurred during the July, 2007 rainfall event. The rest of the projects address either minor deficiencies or proposed development. They can be located on **Figure 5.4-1**. Detailed descriptions of each project are provided within the remainder of this section. Refer to **Figures 5.4-P1** to **5.4-P5** for additional context.

In addition to these specific projects, the four existing drainage systems which discharge to Okanagan Lake should be equipped with units to improve stormwater quality. This can be done as part of the annual capital expenditure program.

Project: EC-01 **Fosbery Road: Mellor to Switchback**

Priority: **3**

Trigger: Fosbery Road upgrade, recurring flooding issues or annual capital expenditure

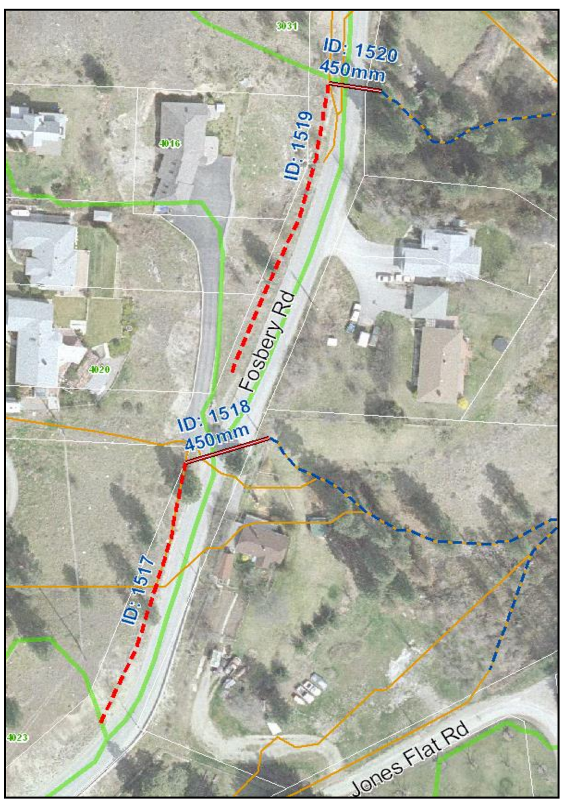
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1517	0.004	-	-	m^3/s
1518	0.008	-	-	m^3/s
1519	0.006	-	-	m^3/s
1520	0.007	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$55,800	$55,800	$55,800

Note: *Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.*



Issue:
There is some risk of runoff crossing Fosbery Road from the west at a variety of locations and entering a development to the east.

Concept:
Define major drainage route to transport runoff across Fosbery Road.

Proposed Works:

Existing System:
Construct two separate ditches along the west side of Fosbery Road and install culverts to direct runoff across the road at the low points.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Fosbery Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: EC-02 Jones Flat Road: East of Tada Ave.

Priority: **3**

Trigger: Fosbery Road, Tada Avenue or Jones Flat Road upgrade, recurring flooding issues or annual capital expenditure

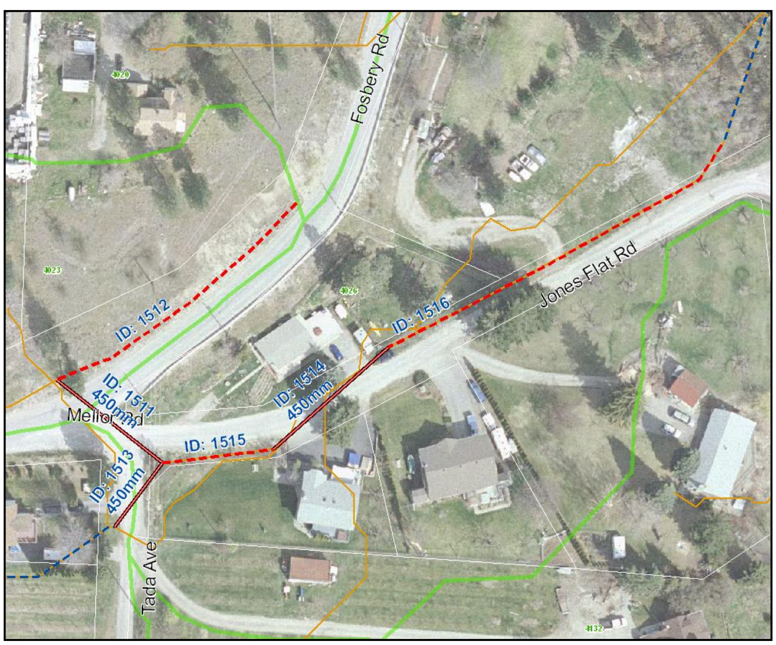
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1511	0.030	-	-	m^3/s
1512	0.001	-	-	m^3/s
1513	0.001	-	-	m^3/s
1514	0.032	-	-	m^3/s
1515	0.031	-	-	m^3/s
1516	0.033	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$96,700	$96,700	$96,700

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
Poorly defined major drainage on Fosbery Road and Tada Avenue increases the risk of runoff crossing Fosbery Road from the north and Tada Avenue from the west, causing flooding.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Construct ditching along the Fosbery and Jones Flat Road and install culverts at the low points.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Fosbery Road, Tada Avenue or Jones Flat Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: EC-03 Fosbery Road: Logie to Mellor

Priority: **3**

Trigger: Fosbery Road upgrade, recurring flooding issues or annual capital expenditure

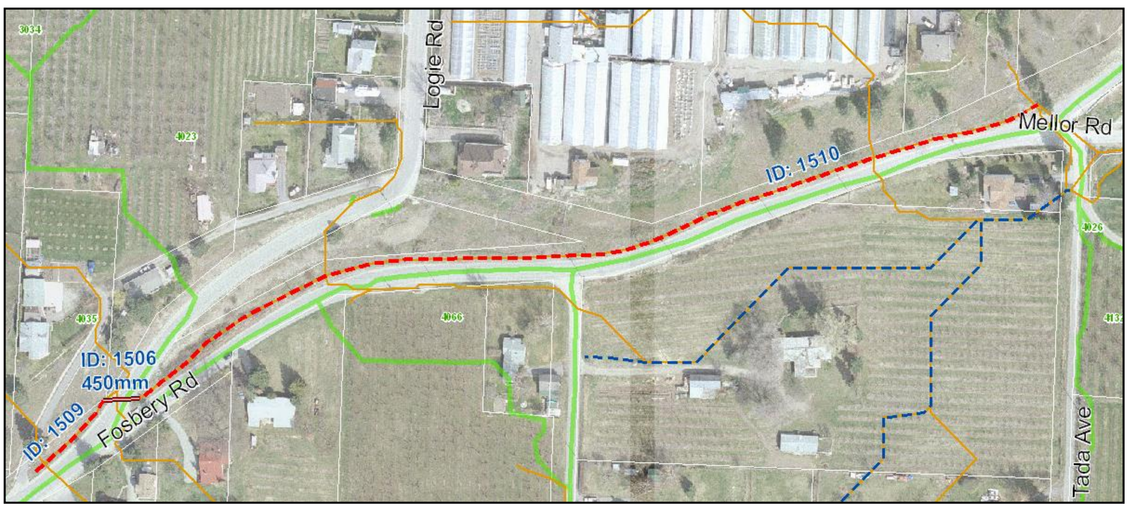
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1506	0.001	-	-	m^3/s
1509	0.001	-	-	m^3/s
1510	0.003	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$32,500	$32,500	$32,500

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:

Poorly defined major drainage along Fosbery Road increases the risk of runoff crossing Fosbery Road from the north and causing damage to private property.

Concept:
Define major drainage route to transport runoff across Fosbery Road.

Proposed Works:

Existing System:
Construct ditching along the north side of Fosbery Road and install a culvert across Logie Road.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Fosbery or Logie Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget
- When the proposed works under Project EC-02 are completed

Project: EC-04 Vanderburgh Avenue

Priority: 3

Trigger: Vanderburgh Avenue upgrade, recurring flooding issues or annual capital expenditure

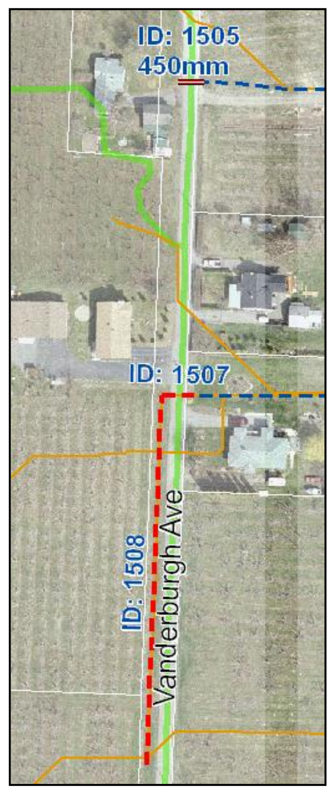
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1505	0.001	-	-	m^3/s
1507	0.007	-	-	m^3/s
1508	0.004	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$22,200	$22,200	$22,200

Note: *Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.*



Issue:
Poorly defined low point with potential for flooding.

Concept:
Define major drainage route to transport runoff across Vanderburgh Avenue.

Proposed Works:

Existing System:
Construct ditching along the west side of Vanderburgh Avenue and a concrete swale or culvert at the low points.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Vanderburgh Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: EC-05 Latimer Avenue at Blewett Road

Priority: **2**

Trigger: Latimer or Blewett Road upgrade, recurring flooding issues or annual capital expenditure

100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1607	0.003	-	-	m^3/s
1888	0.003	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$34,200	$34,200	$34,200

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:
Natural drainage route passes through private property which could result in flooding.

Concept:
Define major drainage route to bypass private property and discharge into ravine.

Proposed Works:

Existing System:
Install a culvert to extend across Latimer and Blewett Roads and a swale from the outfall to the ravine. Property easements will be required for the swale.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Latimer or Blewett Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: EC-06 Bristow Road to Eneas Creek

Priority: **1**

Trigger: Annual capital expenditure and repeated flooding issues.

100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1710	0.020	-	-	m^3/s
1711	0.020	-	-	m^3/s
1712	0.020	-	-	m^3/s
1713	0.018	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$101,400	$101,400	$101,400

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:
The cul-de-sac on Bristow Road is serviced by only a drywell. During the July, 2007 storm, this area was flooded and runoff flowed over the curb and onto private property, causing severe bank erosion. Development below the cul-de-sac limits potential solutions.

Concept:
Construct major drainage to direct runoff away from private property, out of the cul-de-sac and into Eneas Creek.

Proposed Works:

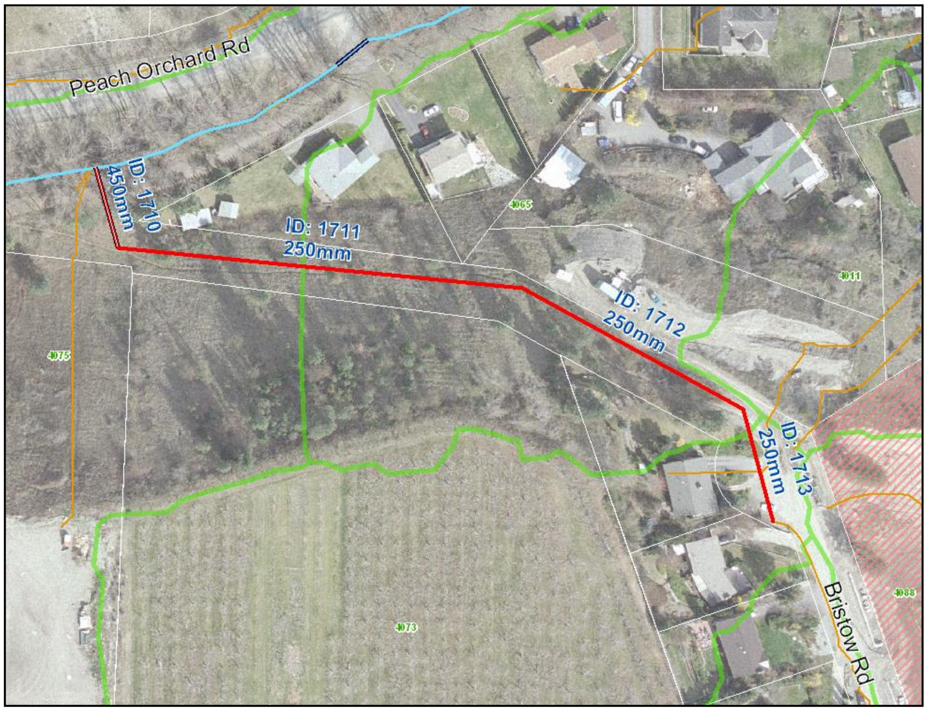
Existing System:
Install piping and culvert along easement from Bristo Road to Eneas Creek.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:

These works should be completed as part of the next annual capital expenditure budget.



Project: EC-07 Blair Street

Priority: 3

Trigger: Blair Road upgrade, recurring flooding issues or annual capital expenditure

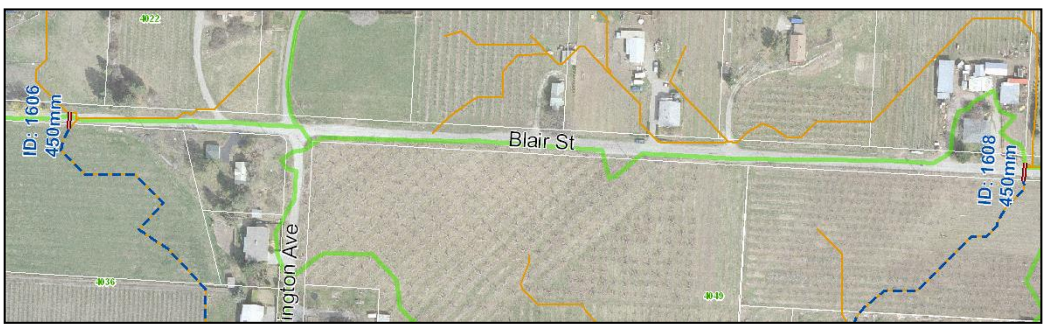
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1606	0.015	-	-	m^3/s
1608	0.045	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$38,300	$38,300	$38,300

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
Poorly defined low points on Blair Road provides potential for runoff to cross the road.

Concept:
Define major drainage route to transport runoff across Blair Road.

Proposed Works:

Existing System:
Install culverts at low points.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:

There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Blair Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: EC-08 Garnet Valley Road at Tingley Street

Priority: **3**

Trigger: Garnet Valley Road or Tingley Street upgrade, recurring flooding issues or annual capital expenditure

100 Year Design Flows:

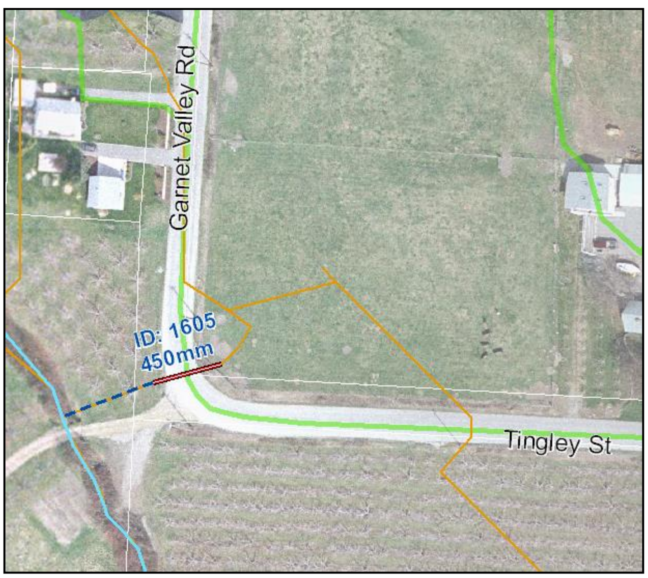
Link ID	Existing	LID	Conventional
1605	0.006	-	-

m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$24,200	$24,200	$24,200

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
Poorly defined low point at the corner of Garney Valley Road and Tingley Street creating a potential for runoff to cross the road or cause flooding.

Concept:
Define major drainage route to transport runoff across road and into Eneas Creek.

Proposed Works:

Existing System:
Install culvert at low point.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Garnet Valley Road or Tingley Street are upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: EC-09 **Garnet Valley Road West of Rattlesnake Mountain: Part 1**

Priority: **2**

Trigger: Development immediately upstream

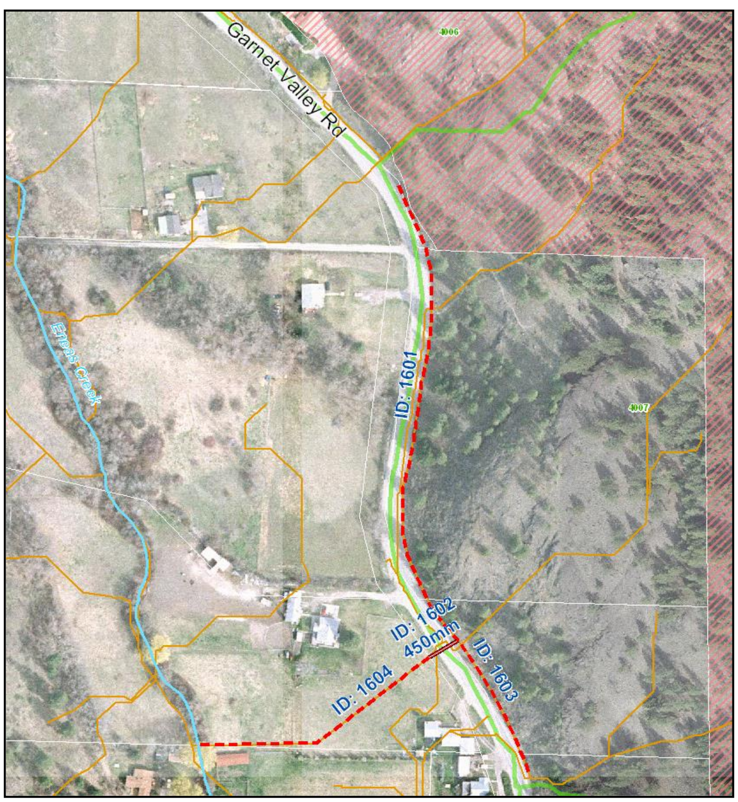
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1601	-	0.005	0.005	m^3/s
1602	-	0.017	0.089	m^3/s
1603	-	0.008	0.078	m^3/s
1604	-	0.019	0.090	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$0	$34,100	$34,100

Note: *Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.*



Issue:
Increased runoff due to large proposed development on Rattlesnake Mountain upstream.

Concept:
Better define major drainage route to contain runoff from the development and discharge it to Eneas Creek.

Proposed Works:

Existing System:
No existing deficiencies are noted.

LID System:
Construct ditching on the east side of Garnet Valley Road with a culvert at the low point to transport runoff across road. Obtain easement and install ditch from outfall to Eneas Creek.

Conventional System:
It is recommended that the development upstream of this project attenuate runoff discharge rates to match those under LID conditions, the infrastructure sizing and hence capital cost will remain unchanged.

Implementation:
Require these works as off-site works for the subject development. Easements will have to be negotiated with the owners of the land between Garnet Valley Road and Eneas Creek, and approval from the Ministry of Environment obtained for the outfall to the creek.

Project: EC-10 Garnet Valley Road West of Rattlesnake Mountain: Part 2

Priority: 2

Trigger: Development immediately upstream

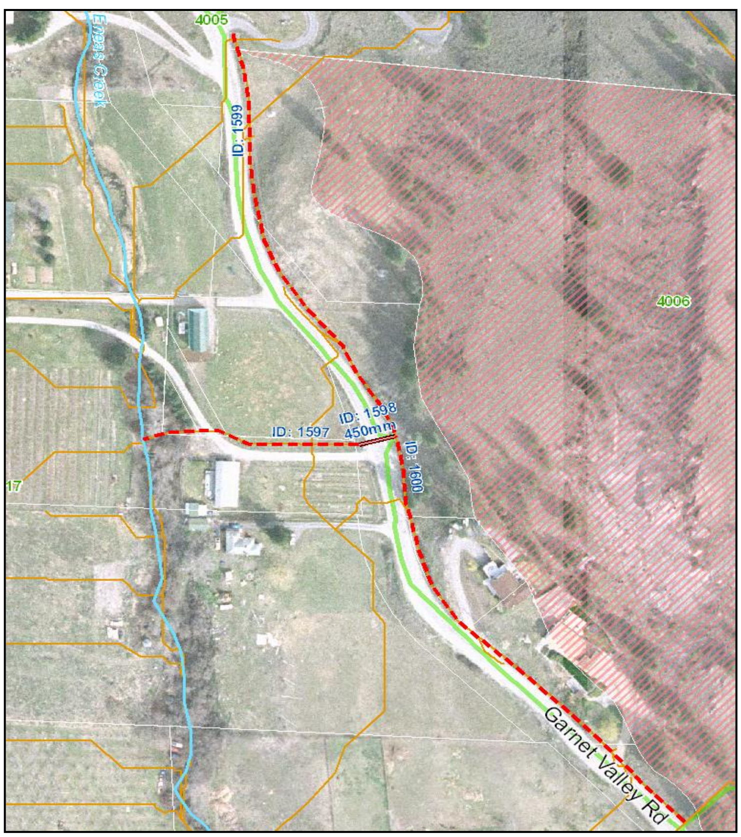
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1597	-	0.016	0.148	m^3/s
1598	-	0.015	0.148	m^3/s
1599	-	0.001	0.035	m^3/s
1600	-	0.001	0.115	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$0	$39,800	$39,800

Note: *Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.*



Issue:
Increased runoff due to large proposed development on Rattlesnake Mountain upstream.

Concept:
Better define major drainage route to contain flow from the development and discharge them into Eneas Creek.

Proposed Works:

Existing System:
No existing deficiencies are noted.

LID System:
Construct ditching on the east side of Garnet Valley Road with a culvert at the low point to transport runoff across road. Obtain easement and install ditch from outfall to Eneas Creek.

Conventional System:
It is recommended that the development upstream of this project attenuate runoff discharge rates to match those under LID conditions, the infrastructure sizing and hence capital cost will remain unchanged.

Implementation:
Require these works as off-site works for the subject development. Easements will have to be negotiated with the owners of the land between Garnet Valley Road and Eneas Creek, and approval from the Ministry of Environment obtained for the outfall to the creek.

Project: EC-11 **Austin Street and Latimer Avenue**

Priority: **3**

Trigger: Road upgrade, recurring flooding issues or annual capital expenditure

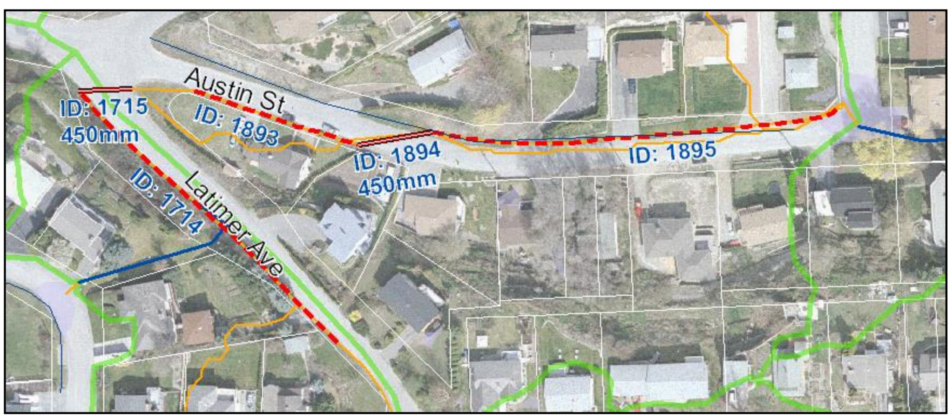
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1714	0.009	-	-	m^3/s
1715	0.012	-	-	m^3/s
1893	0.016	-	-	m^3/s
1894	0.022	-	-	m^3/s
1895	0.030	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$70,400	$70,400	$70,400

Note: *Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.*



Issue:

Poorly defined low points along Austin and Latimer Road with natural drainage routes passing through private property creating the potential for flooding.

Concept:
Define major drainage routes to provide connectivity between Latimer Avenue and Austin Street, and transport runoff to the existing downstream system.

Proposed Works:

Existing System:
Construct ditching along Latimer Avenue and Austin Street with culverts to transport runoff north across both streets as shown.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Latimer Avenue or Austin Street are upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: EC-12 Latimer Avenue between Banks Crescent and Hill Crescent

Priority: **3**

Trigger: Latimer Road upgrade, recurring flooding issues or annual capital expenditure

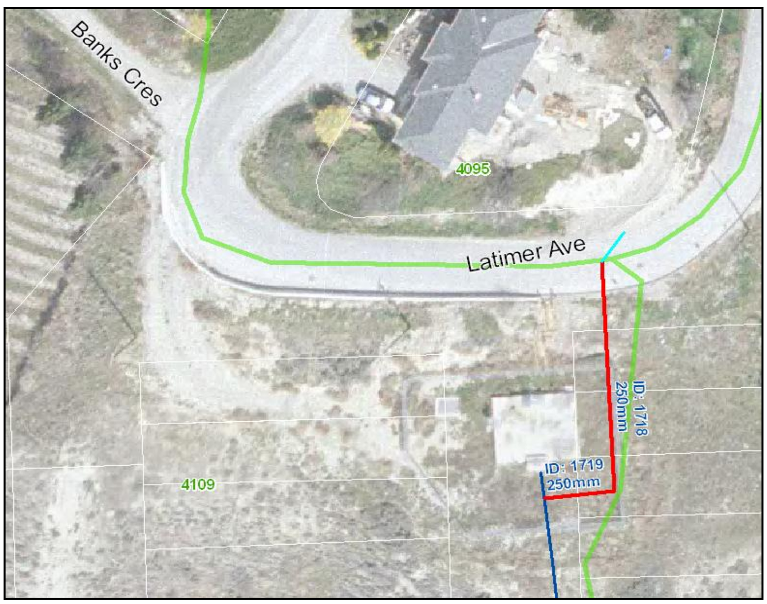
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1718	0.010	-	-	m^3/s
1719	0.010	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$25,900	$25,900	$25,900

Note: *Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.*



Issue:

Low point on Latimer Road has the potential to receive significant run off during storms with little drainage infrastructure.

Concept:
Define major drainage route to transport run off in the existing system downstream.

Proposed Works:

Existing System:
Install piping from low point on Latimer Road to existing system.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Latimer Avenue is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: EC-13 **Phillips Avenue: Hill Crescent to Solly Road**

Priority: **2**

Trigger: Hill Crescent or Philips Avenue upgrade, recurring flooding issues or annual capital expenditure

100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1720	0.008	-	-	m^3/s
1800	0.013	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$7,100	$7,100	$7,100

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:
A significant amount of roadway drains to CBs on either side of the private driveway. Durign the July, 2007 storm event, the capacity of these inlets, and perhaps of the piped system to which they drain, was exceeded and runoff flowed into the garage.

Concept:
Define major drainage route to provide transport of runoff around private property and into existing system downstream. Also improve CB inlet.

Proposed Works:

Existing System:
Re-grade the gutter-line along the driveway to ensure flow from south to north, and create a let-down to the ravine on the north side of the subject property. Upgrade the south CB to a side-inlet catch basin. Construct a ditch on Phillips Avenue to direct overflows to the indicated ROW.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:

Works should be constructed when one of the following occurs:

- Hill Crescent or Philips Avenue are upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: EC-14 MacDonald Place to MacDonald Street

Priority: **2**

Trigger: MacDonald Street or MacDonald Place upgrade, recurring flooding issues or annual capital expenditure

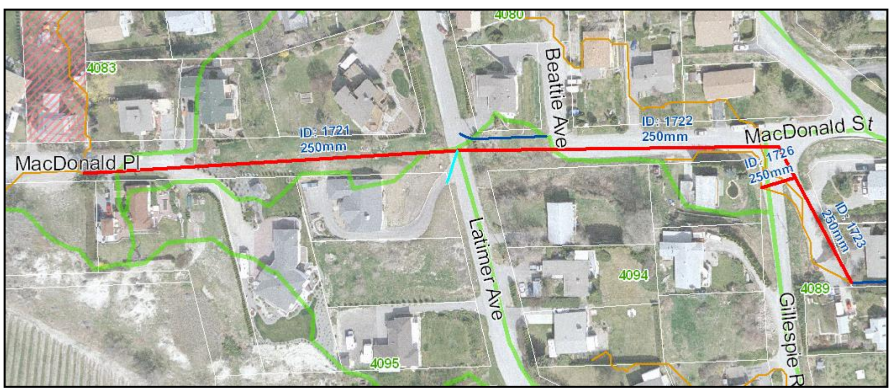
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1721	0.012	0.012	0.012	m^3/s
1722	0.022	0.022	0.022	m^3/s
1723	0.037	0.037	0.037	m^3/s
1726	0.012	0.012	0.012	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$194,500	$194,500	$194,500

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:

Insufficient drainage at low point on MacDonald Place - flooding has been recorded during heavy storms.

Concept:

Define major drainage route to provide connectivity to existing downstream system.

Proposed Works:

Existing System:
Install pipe along and between MacDonald Place and MacDonald Street.

LID System:
Upstream development is not anticipated to impact the proposed works, but they will benefit.

Conventional System:
Upstream development is not anticipated to impact the proposed works, but they will benefit.

Implementation:
Works should be constructed when one of the following occurs:

- MacDonald Place or MacDonald Street is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget
- The proposed development occurs

Project: EC-15 **Inglis Avenue: Faircrest to Gowans**

Priority: **2**

Trigger: Development upstream, Inglis Avenue upgrade

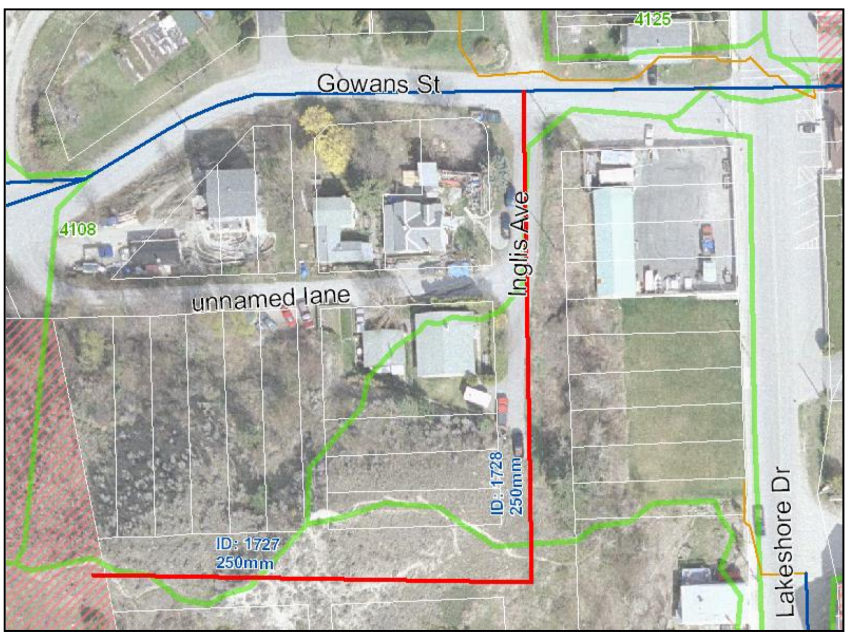
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1727	-	0.011	0.022	m^3/s
1728	-	0.011	0.022	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
-	$99,100	$99,100

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
Lack of drainage infrastructure to convey anticipated runoff from future upstream development.

Concept:
Create both minor and major drainage routes downstream of future development

Proposed Works:

Existing System:
No existing deficiencies.

LID System:
Install pipe from development boundary to, and along, Inglis Avenue. Connect to existing system on Gowans Street.

Conventional System:
It is recommended that the development upstream of this project attenuate runoff discharge rates to match those under LID conditions, therefore, the infrastructure sizing and hence capital cost will remain unchanged.

Implementation:
Require these works as off-site works for the subject development. Easements will have to be negotiated with the owners of the land between Garnet Valley Road and Eneas Creek, and approval from the Ministry of Environment obtained for the outfall to the creek.

5.5 Front Bench Basin

The Front Bench Basin covers approximately 266 hectares and is bounded by Giant's Head Mountain to the west, Highway 97 to the north and east, and a drainage divide to the south.

5.5.1 Existing Drainage

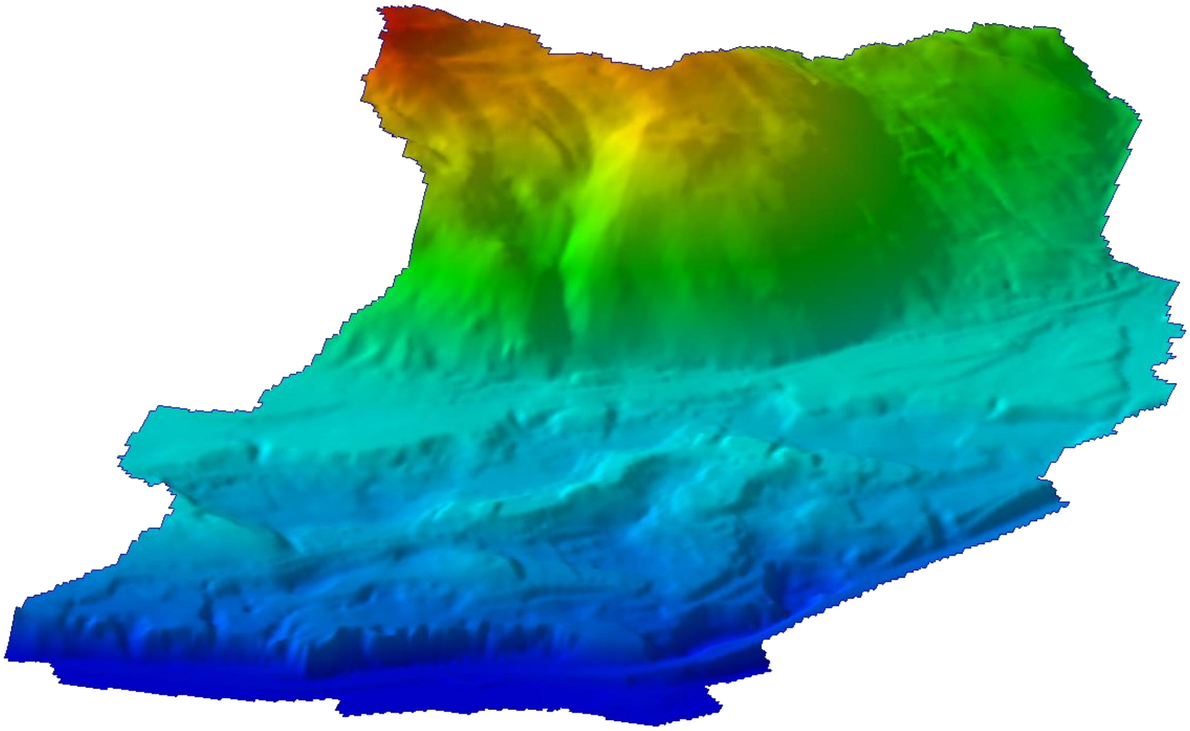
This basin is not characterized by a perennial stream nor by well-defined ravines. Instead, several poorly defined surface drainage routes extend from the base of Giants Head Mountain, through wide ravines, over the silt bluffs, into the ditch on the western side of Highway 97, and ultimately, through large culverts into Okanagan Lake. The majority of surface runoff generated in the Front Bench basin infiltrates before reaching the ditches along Highway 97. Water that does enter these ditches is typically generated on the highway. Natural benches, which step down from Giants Head Mountain towards the lake, also contain a few large, natural depressions. These depressions function as natural retention ponds and allow surface runoff to collect and infiltrate into the ground.

Most of the roads within the Front Bench basin have rural cross sections. Asphalt and concrete curbs have been utilized in select locations, however, to either:

- Manage flows on steeper road sections, or to
- Service development.

There is very little drainage infrastructure within this basin with the majority of surface run off from impervious areas being captured in dry wells. A few small-diameter pipes have been installed, presumably to address localized ponding issues. **Figure 5.5.1** shows the topography of the Front Bench basin.

Figure 5.5.1
Topography of Front Bench Basin. Blue to red represents increasing elevation.



5.5.2 Land Use

Existing

The north eastern slope of Giants Head Mountain is currently undeveloped and is sparsely covered with coniferous trees, tuft grasses, and occasional exposed rock. The benches are comprised of agricultural land with pockets of low-density and rural residential development. A very small amount of medium-density residential development is sandwiched between Hespeller and Giants Head Roads along the northwest boundary of the basin.

Since the natural topography includes wide ravines and depressions, development has occurred within them. In some cases, this has resulted historical flooding. The most significant instance of this occurred in July, 2007 at Jewel Place. The fact that this was the only flooded area during this event indicates that the existing soils have sufficient capacity to accommodate rainfall from at least a 100 year storm event.

Future

At present, only one area has been identified for potential future development. As shown in **Figure 5.5-2,** it is located directly south of, and adjacent to the Jewel Place development. It is expected to be low-density residential.

5.5.3 Infiltration Potential

Surficial Soils

The soils data obtained for this study do not include a drainage classification for Giants Head mountain. As shown in **Figure 5.5-3**, however, the benches below the mountain are classified as well drained to rapidly drained. The silt bluffs along the eastern boundary of the basin are classified as moderately drained to well drained.

Groundwater Conditions

In general, groundwater seems to remain well below the ground surface. No perennial or ephemeral streams, nor any groundwater discharge areas were noted.

Conclusion

Conditions for discharging stormwater to ground are probably suitable for the bench lands between Giants Head Mountain and the silt bluffs. In all cases, however, a detailed site investigation should be conducted by a qualified hydro-geologist to confirm local site suitability whenever infiltration systems are proposed.

5.5.4 Analysis

The basin presents several stormwater management challenges:

- Pockets of low density and rural residential development, some of which are located within natural drainage paths or depressions.
- Steep slopes on Giants head which might generate large volumes of runoff during high intensity storms.

Analysis indicates that:

- Runoff generated on Giants Head Mountain and on the rural roads tends to infiltrate quickly as it flows overland and through natural swales.
- There is insufficient infiltration capacity within the Jewel Place depression to accommodate all of the runoff that might flow into it. Therefore, drainage works are proposed to address this issue.
- Most of the drainage is routed to the ditch along Highway 97 via four routes. Two of these are naturally over the silt bluffs. Potential future flows could cause erosion unless works are implemented to protect the bluffs.

5.5.5 Projects

Twelve projects were recommended for this basin:

- One Priority 1 project to address a significant existing deficiency as well as to service future development,
- One Priority 2 project to address drainage from future development,
- Two Priority 2 projects to address minor deficiencies revealed during the July, 2007 storm, and
- Eight Priority 3 projects to improve major drainage route definition and connectivity. All of these are allocated to address existing deficiencies.

The remainder of this section presents the details of each proposed improvement within the Front Bench basin. These can be located on **Figure 5.5-1** and examined in more detail on **Figures 5.5-P1** to **5.5-P2**.

Project: FB-01 **Fuller Street: Front Bench to Walters/Hwy 97**

Priority: **3**

Trigger: Fuller Road or Front Bench Road upgrade, recurring flooding issues or annual capital expenditure.

100 Year Design Flows:

Link ID	Existing	LID	Conventional	
980	0.002	-	-	m^3/s
981	0.049	-	-	m^3/s
982	0.052	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$108,100	$108,100	$108,100

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:
Low points at the intersection of Fuller Street and Front Bench Road direct runoff to natural drainage routes through private property. There is potential for flooding and erosion to occur during heavy storms.

Concept:
Because of how the downstream property has been developed, providing a surface major drainage route may be difficult. Therefore, construct a piped major drainage route. Note that there appears to be a ROW from Front Bench Road to the highway.

Proposed Works:

Existing System:
Install a pipe across the intersection of Fuller Street and Front Bench Road, and continue down to the west ditch along Highway 97.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Fuller Street or Front Bench Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget
- Projects FB-03 is constructed.

Project: FB-02 Giants Head Road to Harris Road

Priority: 3

Trigger: Giants Head Road upgrade, recurring flooding issues or annual capital expenditure

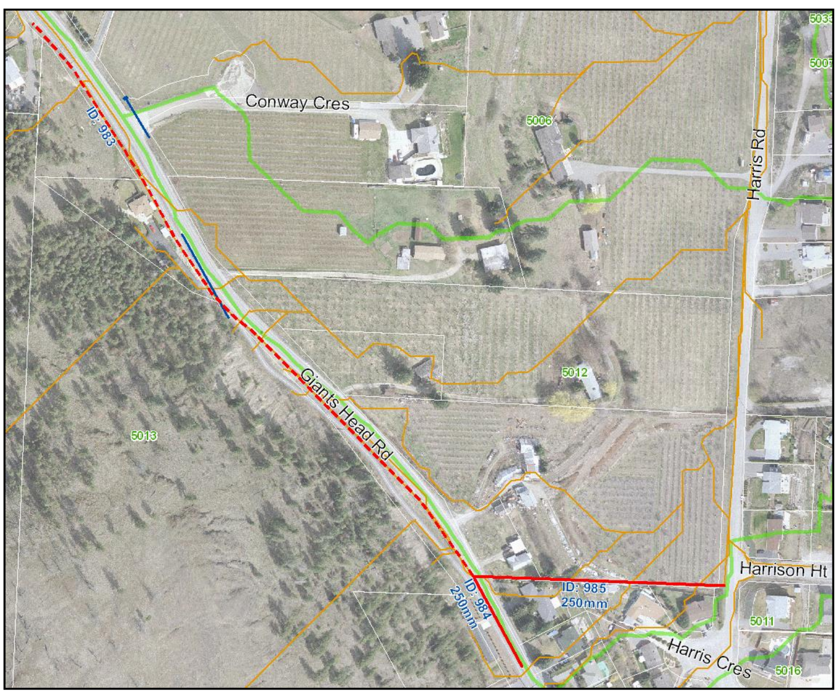
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
983	0.040	-	-	m^3/s
984	0.002	-	-	m^3/s
985	0.027	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$132,200	$132,200	$132,200

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
Poorly defined low points along Giants Head Road which could result in runoff crossing the road and flooding downstream properties.

Concept:
Define major drainage route between Giants Head Road and Harris Road. Note that because of existing development, a piped major drainage route is recommended.

Proposed Works:

Existing System:
Construct ditching along the west side of Giants Head Road and connect to future works on Harris Road (see FB-03) via a storm sewer.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Fuller Street or Front Bench Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: FB-03 **Harris Road: Harrison to Fuller**

Priority: **3**

Trigger: Harris Road upgrade, recurring flooding issues or annual capital expenditure

100 Year Design Flows:

Link ID	Existing	LID	Conventional	
986	0.052	-	-	m^3/s
987	0.045	-	-	m^3/s
988	0.043	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$48,500	$48,500	$48,500

Note: *Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.*

Issue:
Poorly defined low points along Harris Road which could result in runoff crossing the road or flooding downstream properites.

Concept:
Define major drainage route between Harris Road and Fuller Street.

Proposed Works:

Existing System:
Construct ditching along the western side of Harris Road and a culvert near the intersection of Fuller Street.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:

Works should be constructed when one of the following occurs:

- Fuller Street or Front Bench Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget
- Projects FB-02 is constructed.

Project: FB-04 **Front Bench Road to Walters Road near Impett Place**

Priority: **3**

Trigger: Walters Road upgrade, recurring flooding issues or annual capital expenditure

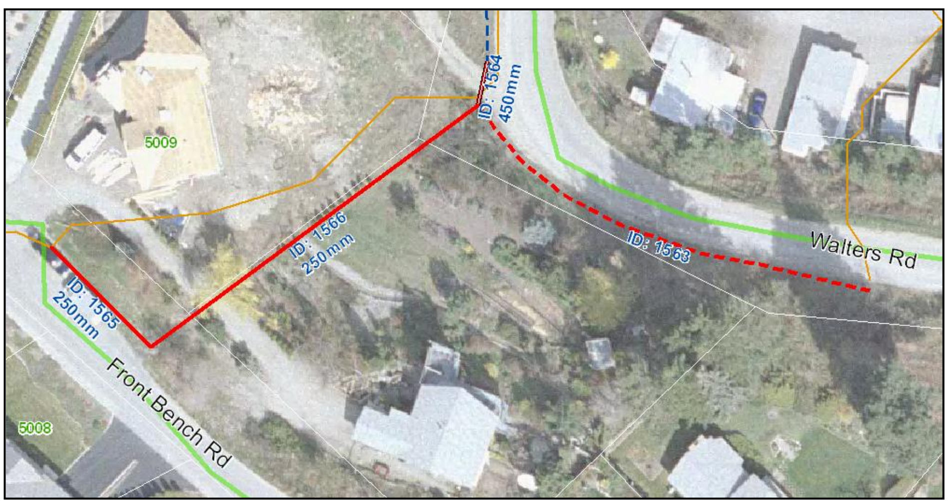
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1563	0.015	-	-	m^3/s
1564	0.010	-	-	m^3/s
1565	0.004	-	-	m^3/s
1566	0.005	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$59,400	$59,400	$59,400

Note: *Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.*



Issue:
Natural drainage route passes through private property.

Concept:
Construct piped major drainage route between Front Bench Road and Walters Road.

Proposed Works:

Existing System:
Install inlets and storm sewer along Front Bench Road and down to Walters Road. Construct ditching along the south side of Walters Road to the indicated driveway culvert.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Walters Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: FB-05 **Wilson Road/Holder Avenue: Walters to Hwy 97 (Jewel Place)**

Priority: **1**

Trigger: Existing deficiency and current upstream development

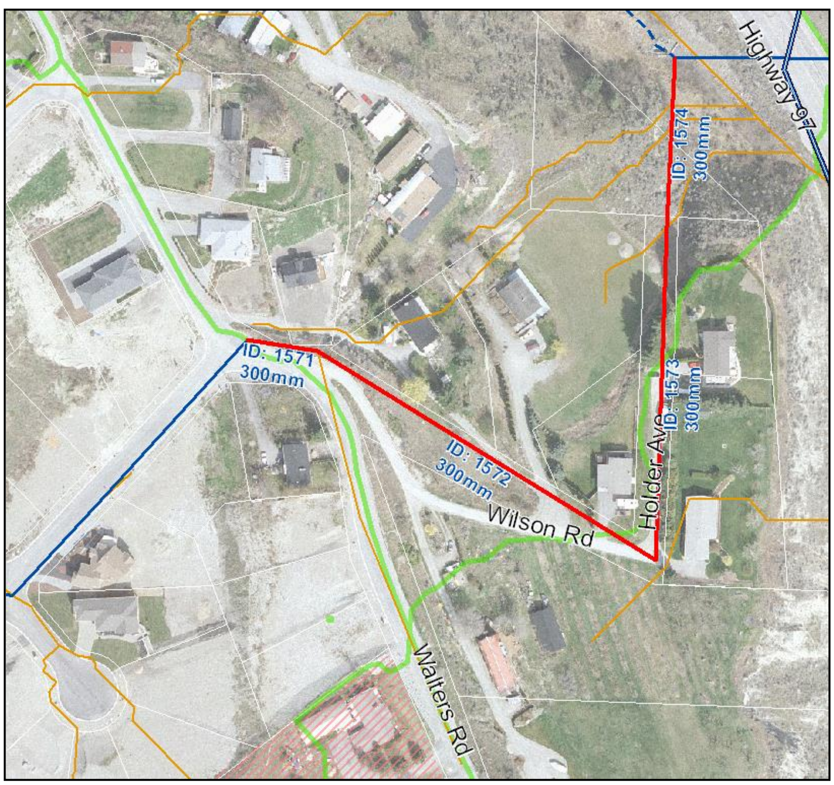
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1571	0.027	0.027	0.027	m^3/s
1572	0.056	0.056	0.056	m^3/s
1573	0.061	0.061	0.061	m^3/s
1574	0.062	0.062	0.062	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$446,300	$446,300	$446,300

Note: *Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.*



Issue:
Jewel Place is constructed in a large sink (depression) which currently relies on drywells for drainage. During the July, 2007 storm event, this area was severely flooded. In addition, new development immediately to the south of Jewel Place is being constructed, so downstream drainage is required.

Concept:
Construct a major drainage route between Walters Road and Highway 97. Note that because of the steep slopes and potential for erosion of the silt bluffs, a piped system is proposed.

Proposed Works:

Existing System:
Install a storm sewer on Wilson Road and Holder Avenue from Walter Road to the existing culvert crossing Highway 97. Tie into the storm Jewel Place storm sewer system at Walters Road and install dual side-inlet CBs to capture major runoff. Due to steep grades, an energy dissipation structure will be required at the corner of Wilson Road and Holder Avenue.

LID System:
Upstream development is not anticipated to impact the proposed works, but it will benefit from them.

Conventional System:
It is recommended that the development upstream of this project attenuate post-development runoff discharge rates to match those under LID conditions. Therefore, the infrastructure sizing and corresponding capital costs will remain unchanged.

Implementation:
These works should be completed as soon as they can be funded.

Project: FB-06 Walters Road: South of Wilson

Priority: **2**

Trigger: Development along Walters Road

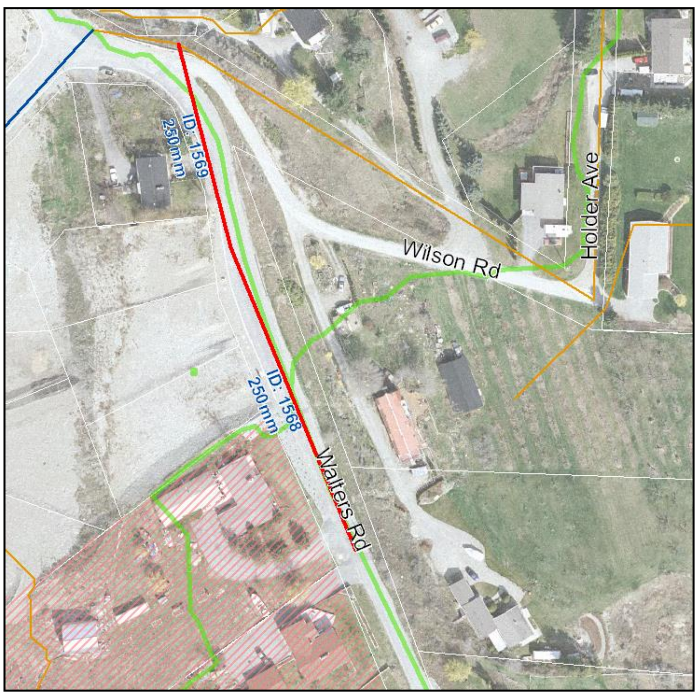
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1568	-	0.020	0.020	m^3/s
1569	-	0.024	0.024	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
-	$85,500	$85,500

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:

Insufficient drainage infrastructure along Walters Road to accommodate runoff from future development, creating a potential for flooding and/or flow across Walters Road.

Concept:
Walters Road can function as the major drainage route, however, a piped drainage system should be constructed on Walters Road to accommodate minor system flows.

Proposed Works:

Existing System:
No existing deficiencies.

LID System:
Install a storm sewer on Walters Road from the development access road to the Wilson Road intersection.

Conventional System:
It is recommended that the development upstream of this project attenuate runoff discharge rates to match those under LID conditions. Therefore, the infrastructure sizing and hence capital cost will remain unchanged.

Implementation:
Require these works as part of the off-site works associated with the proposed development. Note that Project FB-05 must be constructed first.

Project: FB-07 Newton Road and Orr Place

Priority: 2

Trigger: Newton, Happy Valley Road or Orr Place upgrade, recurring flooding issues or annual capital expenditure

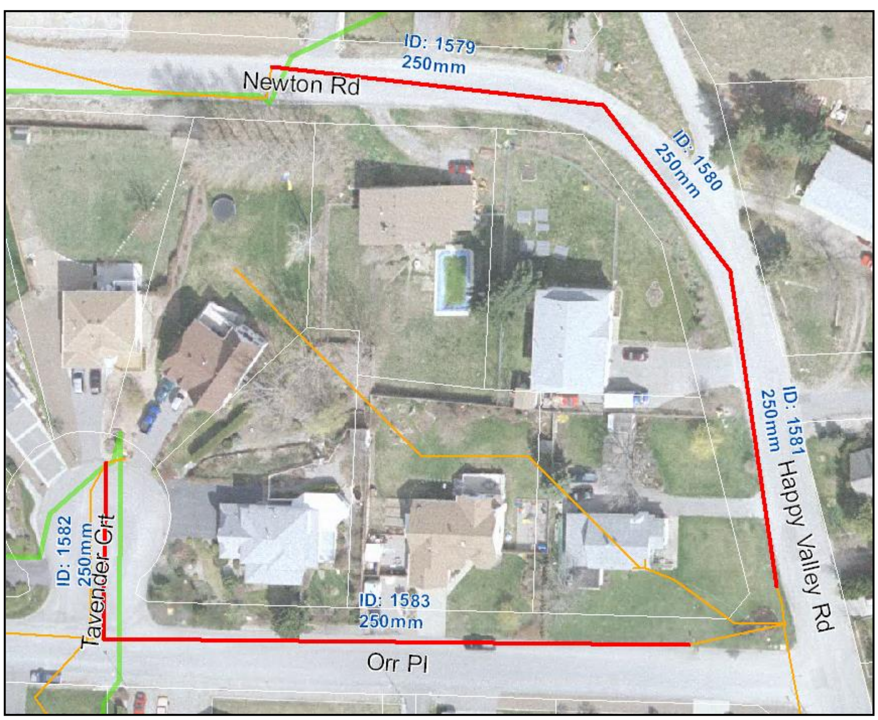
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1579	0.024	-	-	m^3/s
1580	0.024	-	-	m^3/s
1581	0.024	-	-	m^3/s
1582	0.002	-	-	m^3/s
1583	0.019	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$231,800	$231,800	$231,800

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
Insufficient drainage infrastructure at low points on Newton Road and Tavender Court has led to flooding during heavy storms. Runoff from the Newton Road low point is directed onto private property.

Concept:
Construct a piped major drainage system from the low points to Happy Valley Road.

Proposed Works:

Existing System:
Install piping along Newton Road, Happy Valley Road, Tavender Court and Orr Place. Include curb, gutter, and side-inlet CBs where appropriate.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Newton, Happy Valley Road or Orr Place is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Note that Project FB-10 must be completed first.

Project: FB-08 **Eden Road:Happy Valley to Front Bench**

Priority: **3**

Trigger: Eden Road upgrade, recurring flooding issues or annual capital expenditure

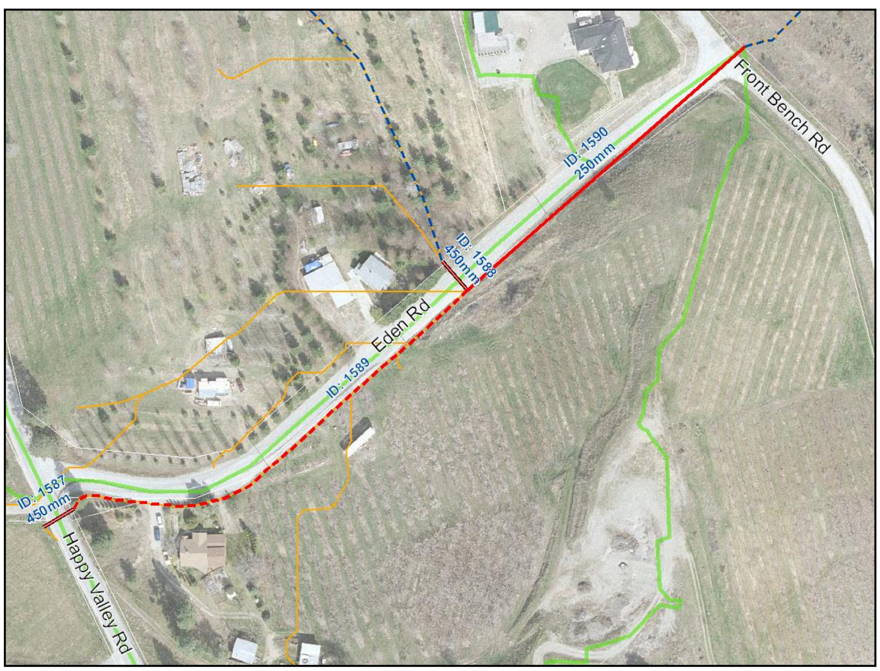
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1587	0.001	-	-	m^3/s
1588	0.001	-	-	m^3/s
1589	0.015	-	-	m^3/s
1590	0.016	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$124,100	$124,100	$124,100

Note: *Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.*



Issue:
There is a low point on Eden Road with no downstream drainge route. There is potential for runoff to cross the road, enter private property, and cause flooding.

Concept:
Define major drainage route along Eden Road to provide a means for runoff to be safely directed downstream

Proposed Works:

Existing System:
Install a culvert across Happy Valley Road, ditching and piping along Eden Road, and a culvert across Front Bench Road.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Eden Road or Happy Valley Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: FB-09 **Giants Head Road to Happy Valley Road past Cemetary**

Priority: **3**

Trigger: Giants Head or Happy Valley Road upgrade, recurring flooding issues or annual capital expenditure.

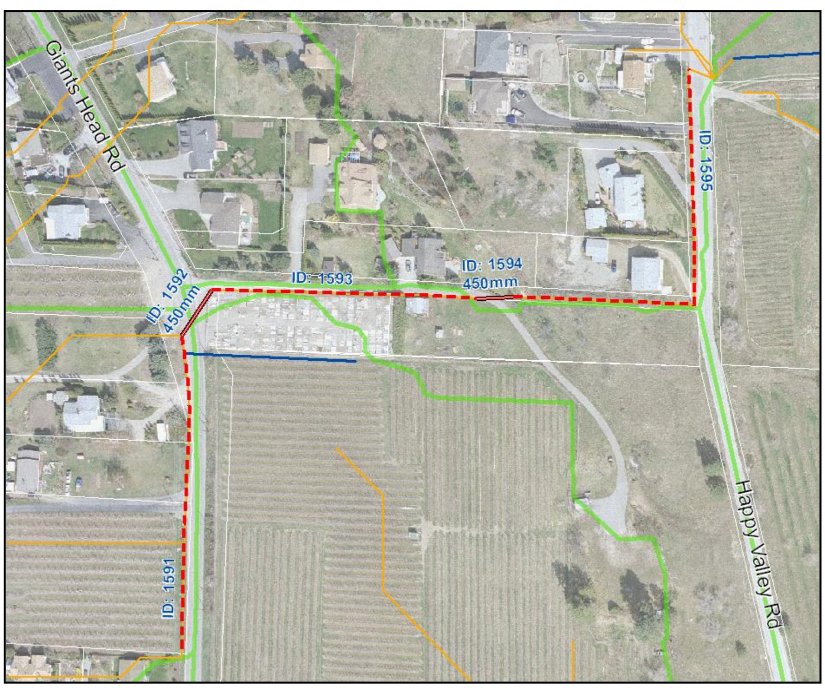
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1591	0.005	-	-	m^3/s
1592	0.006	-	-	m^3/s
1593	0.006	-	-	m^3/s
1594	0.003	-	-	m^3/s
1595	0.012	-	-	m^3/s
1630	0.012	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$101,800	$101,800	$101,800

Note: *Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.*



Issue:

Poorly defined low points along Giants Head Road pose potential risks of runoff crossing the road and flooding downstream properties.

Concept:

Define major drainage route between Giants Head Road and Happy Valley Road. Keep route on ROWs.

Proposed Works:

Existing System:

Construct ditching along Giants Head Road, down ROW, and along Happy Valley Road. Install a culvert from the west side of Giants Head Road to the north side of the cemetery. Install driveway culverts as required. The CB at the low point on Happy Valley Road might require an upgrade to a side-inlet model.

LID System:

There is no anticipated development upstream of the proposed works.

Conventional System:

There is no anticipated development upstream of the proposed works.

Implementation:

Works should be constructed when one of the following occurs:

- Giants Head Road or Happy Valley Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: FB-10 **Happy Valley Road: South of Orr Place**

Priority: **2**

Trigger: Construction of Project FB-07

100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1584	0.043	-	-	m^3/s
1585	0.055	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$45,200	$45,200	$45,200

Note: *Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.*

Issue:
Lack of drainage infrastructure downstream of proposed works under project FB-07.

Concept:
Improve major drainage route definition and connectivity

Proposed Works:

Existing System:
Install culvert across Orr Place Road and ditching along west side of Happy Valley Road. The CB at the low point on Happy Valley Road might require an upgrade to a side-inlet model.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Project FB-07 is completed
- Happy Valley Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: FB-11 Giants Head Road: North of Cemetary

Priority: 3

Trigger: Giants Head Road upgrade, recurring flooding issues or annual capital expenditure

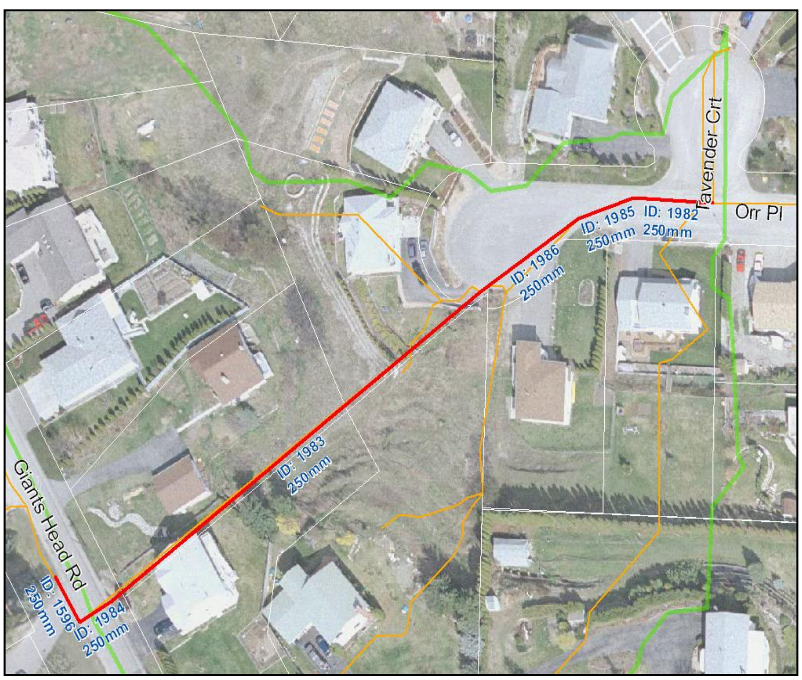
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1596	0.001	-	-	m^3/s
1982	0.002	-	-	m^3/s
1983	0.002	-	-	m^3/s
1984	0.002	-	-	m^3/s
1985	0.002	-	-	m^3/s
1986	0.002	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$102,000	$102,000	$102,000

Note: *Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.*



Issue:
Poorly defined drainage route from low point on Giants Head Road to Orr Place increases the risk of runoff crossing road and flooding downstream properties.

Concept:
Cosntruct a piped major drainage route between Giants Head Road and Orr Place.

Proposed Works:

Existing System:
Install piping from low point on Giants Head Road, along property boundary, and down to Orr Place. Tie into the works proposed in Project FB-07.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Giants Head Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Note that Projects FB-07 and FB-10 must be constructed first.

Project: FB-12 Walters Road: South End to Hwy 97

Priority: 3

Trigger: Recurring flooding issues, silt bluff instability concerns or future development.

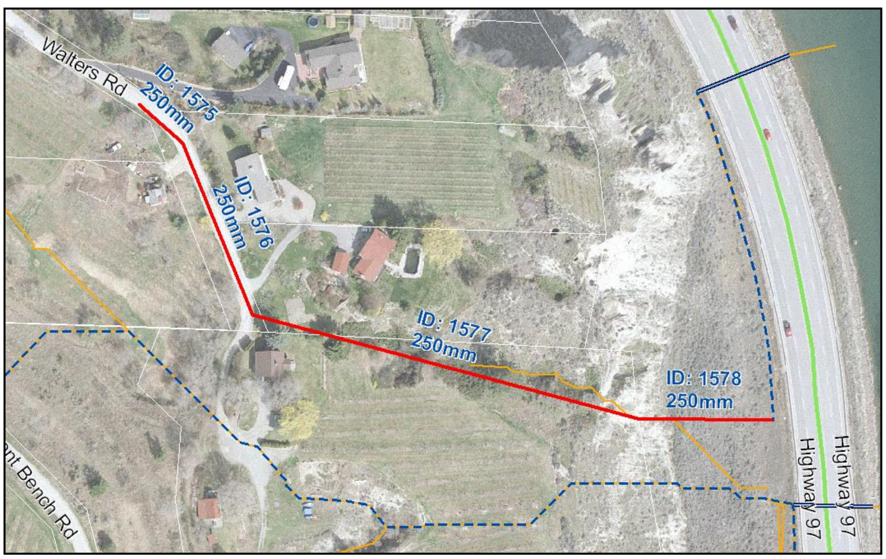
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1575	0.002	-	-	m^3/s
1576	0.003	-	-	m^3/s
1577	0.007	-	-	m^3/s
1578	0.007	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$362,800	$362,800	$362,800

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:

Walters Road currently has a rural cross section, but still slopes downward, ending at private property. Should this road ever be upgraded to an urban section, or should development of the properties to the west occur, potential runoff increases would pose a risk to the stability of the silt bluffs.

Concept:
Construct a piped major drainage system from Walters Road to Highway 97 below silt bluffs.

Proposed Works:

Existing System:
Install a storm sewer, curbs, gutters, and CBs on Walters Road. Tie this system into a piped system drilled through the bluffs to the west ditch of Highway 97. (Drilling is recommended since an open-cut of the silt bluffs is not.) Due to the complexity of this project and concerns over soil instability, a geotechnical investigation is recommended prior to detailed design.

LID System:
Currently, no development upstream of the proposed works is anticipated.

Conventional System:
Currently, no development upstream of the proposed works is anticipated.

Implementation:
Works should be constructed when one of the following occurs:

- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget
- Significant future development occurs upstream.

Should development be proposed upstream, these works could be required as part of the off-site works triggered by the development.

5.6 Giants Head Basin

The Giants Head basin covers approximately 209 hectares and is located on a plateau above the silt bluffs west of Highway 97.

5.6.1 Existing Drainage

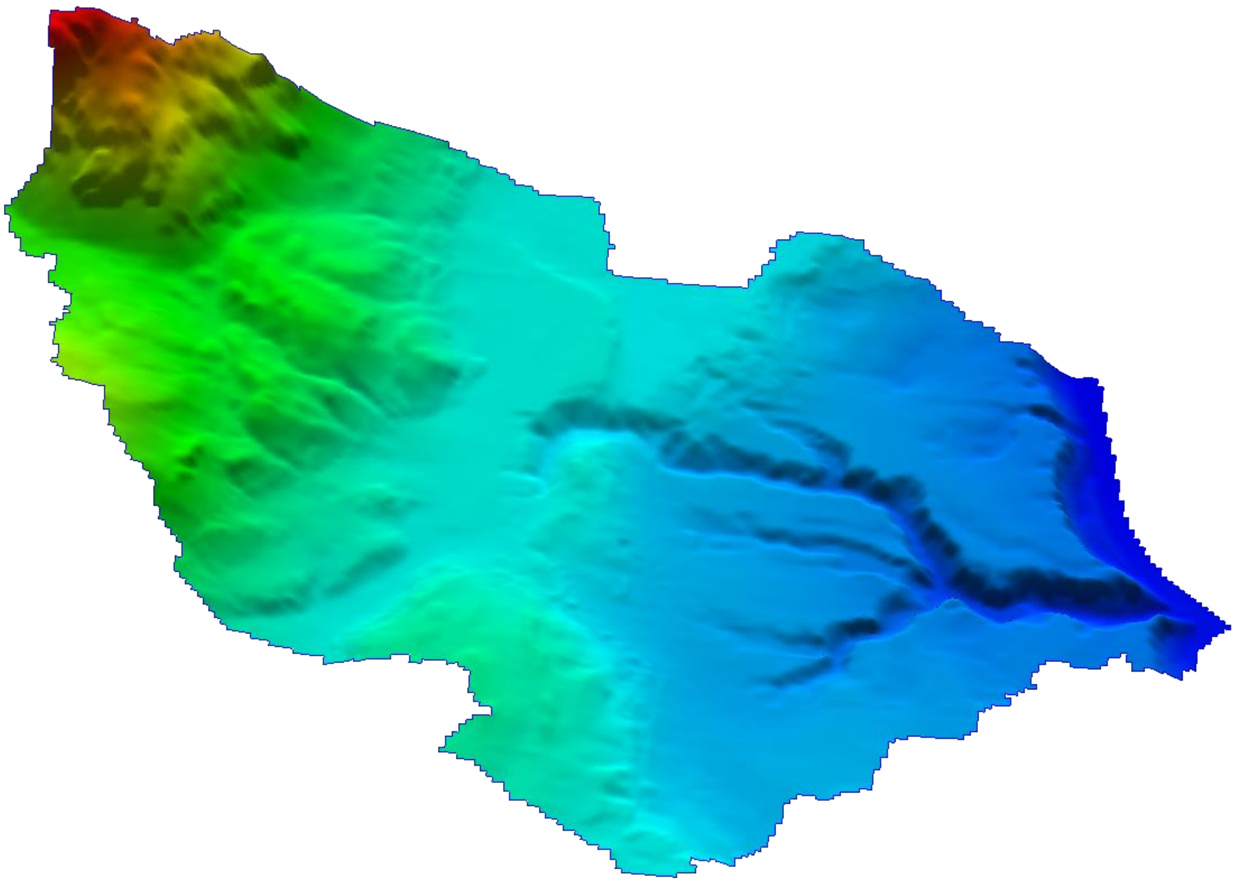
There are no perennial streams within the Giants Head basin, however, a large network of ravines known as Zimmerman's Gulch forms the major drainage route through the silt bluffs to the ditch along the west side of Highway 97. Ultimately, the basin is drained through a 600mm CSP culvert that discharges into Lake Okanagan north of the existing RV campground.

Referring to **Figure 5.6.1**, one can see that primary ravine, at one time, used to extend up onto Gaints Head Mountain. Over the years, part of this ravine was filled-in – probably to create more agricultural land. On July 19th, 2007, a couple of properties located within the low point of the in-filled ravine, were damaged by surface runoff. (A detailed discussion about this event is provided in **Appendix F.**)

Most of the roads within the basin have rural cross sections, although asphalt curbs have been used in select locations to manage flows on steeper road sections. Therefore, drainage consists primarily of natural ravines, constructed open channels, and culverts. A few independent pipes have been installed in various locations – presumably to address localized ponding or drainage flows. These typically discharge onto private land or into a ravine.

In general, however, it appears that most rainfall is absorbed by the surface soil layer or retained within shallow depressions. Flow through the existing highway culvert appear to be generated on the highway surface rather than within the Giants Head basin.

Figure 5.6.1
Topography of Giants Head Basin. Blue to red represents increasing elevation.



5.6.2 Land Use

Existing

The upper slopes of Giants Head Mountain consist primarily of exposed or shallow bedrock, sparsely covered with coniferous trees and tuft grass. Agricultural land extends from the base of the mountain to the silt bluffs, while the large ravines are covered in natural vegetation. Low density and rural residential is located mostly along the rural roads.

Future

The only identified future development is a medium-sized residential development proposed on Giants Head Mountain directly west of Fenner Street. Part of this parcel would drain into the Kevin Brook basin, but part is also within the Giants Head basin.

5.6.3 Infiltration Potential

Surficial Soils

Figure 5.6-3 shows that the soils on Giants Head Mountain have not be classified with respect to drainage characteristics. Field reconnaissance and ortho photos indicated, however, that there is a significant amount of exposed bedrock. Most of the agricultural lands are classified as being well to rapidly drained. The gulch ravines and silt bluffs are classified as being moderately to well drained.

Groundwater Conditions

There are no perennial streams within the basin, and no evidence of springs or ephemeral streams. Therefore, it is assumed that groundwater is well below the ground surface.

Conclusion

Conditions for discharging stormwater to ground are probably suitable for the bench lands between Giants Head Mountain and the silt bluffs. In all cases, however, a detailed site investigation should be conducted by a qualified hydro-geologist to confirm local site suitability whenever infiltration systems are proposed.

5.6.4 Analysis

The basin presents several stormwater management challenges:

- Large area of bedrock on the steep slopes of Giants Head have the potential to produce significant volumes of runoff during high intensity storms.
- Silty soils are predominant within the many ravines, and are susceptible to erosion.
- The basin is located on a plateau above the silt bluffs , so a few drainage routes pass directly over them.
- Some development exists within natural flow routes, and are therefore at risk to flooding damage during high intensity storms.

Analysis indicates that:

- Runoff generated on the exposed rock of Giants Head Mountain tends to infiltrate through the talus rock and well-drainage soils at the base of the mountain.
- Runoff generated on the impervious areas also infiltrates as it flows over the agricultural lands and through the many natural ravines and gullies.
- Areas where the surface organic soils layer is stripped away are susceptible to significant runoff and severe erosion under high intensity rainfall events.
- Significant upgrades to service future development are not necessary as long as on-site measures are taken to reduce peak flows to those calculated using the unit runoff rates recommended in **Section 4.4**.

5.6.5 Projects

Nine projects were recommended for this basin:

- Three Priority 2 project to deficiencies revealed during the July, 2007 storm. Two of these projects will also service future development.
- Six Priority 3 projects to improve major drainage route definition and connectivity. All of these are allocated to address existing deficiencies.

The remainder of this section presents the details of each proposed improvement within the basin. These can be located on **Figure 5.6-1** and examined in more detail on **Figures 5.6-P1** to **5.6-P2**.

Project: GH-01 **Front Bench Road: North of Caldwell Avenue**

Priority: **3**

Trigger: Front Bench Road upgrade, recurring flooding issues or annual capital expenditure

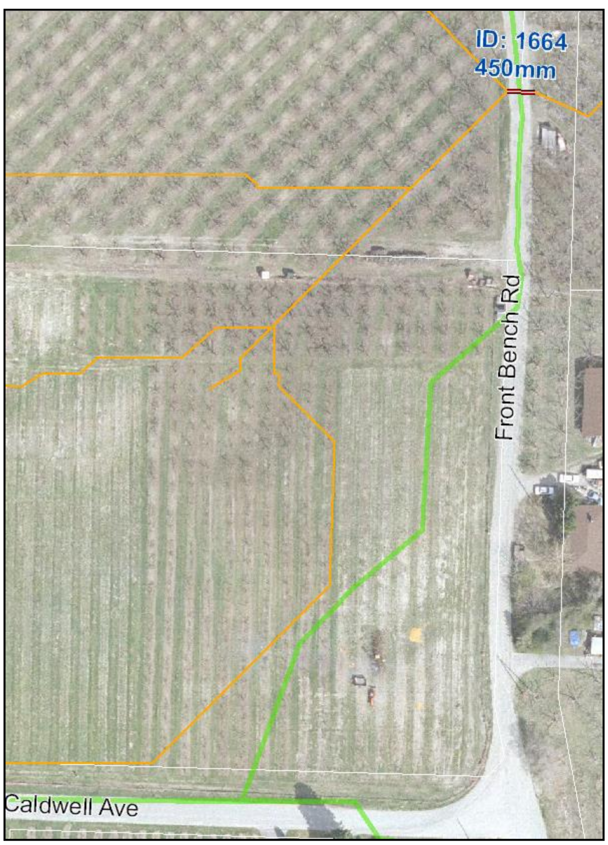
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1664	0.015	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$18,300	$18,300	$18,300

Note: *Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.*



Issue:
No culvert at the low point on Front Bench Road.

Concept:
Install culvert to better define major drainage route and connectivity.

Proposed Works:

Existing System:
Install culvert across Front Bench Road at low point.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Front Bench Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: GH-02 Happy Valley Road / Caldwell Avenue

Priority: 3

Trigger: Happy Valley Road or Caldwell Avenue upgrade, recurring flooding issues or annual capital expenditure

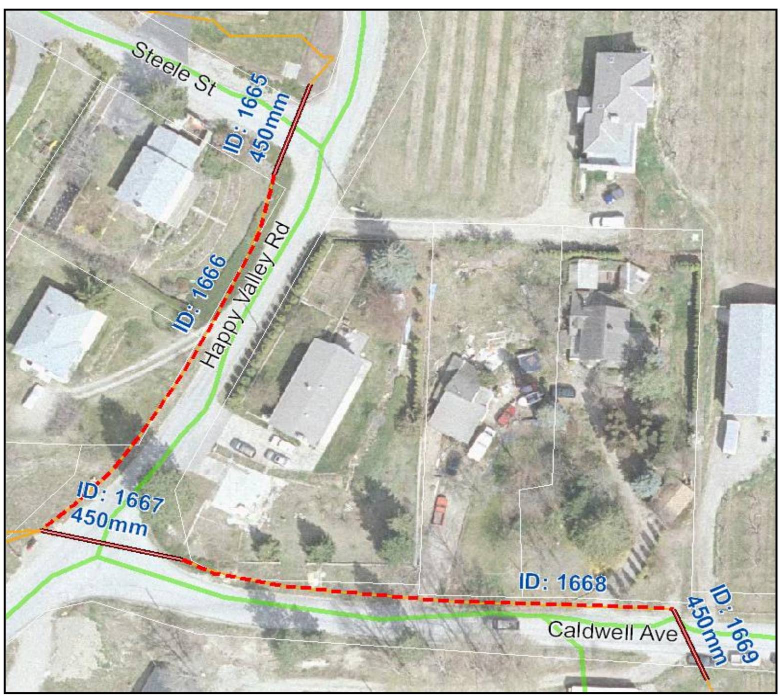
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1665	0.001	-	-	m^3/s
1666	0.003	-	-	m^3/s
1667	0.006	-	-	m^3/s
1668	0.008	-	-	m^3/s
1669	0.008	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$90,500	$90,500	$90,500

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
Poorly defined major drainage route along Happy Valley Road and Caldwell Avenue, which could result in runoff crossing the roads causing damage to private property.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Construct ditching along the west side of Happy Valley Road, a culvert across to east side at the intersection with Caldwell Road, ditching along the north side of Caldwell Road, and finally a culvert discharging into the natural drainage route on the south side. Install driveway culverts as required.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Happy Valley Road or Caldwell Avenue is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: GH-03 **White Street: East of Robertson Avenue**

Priority: 3

Trigger: White Street upgrade, recurring flooding issues, or annual capital expenditure

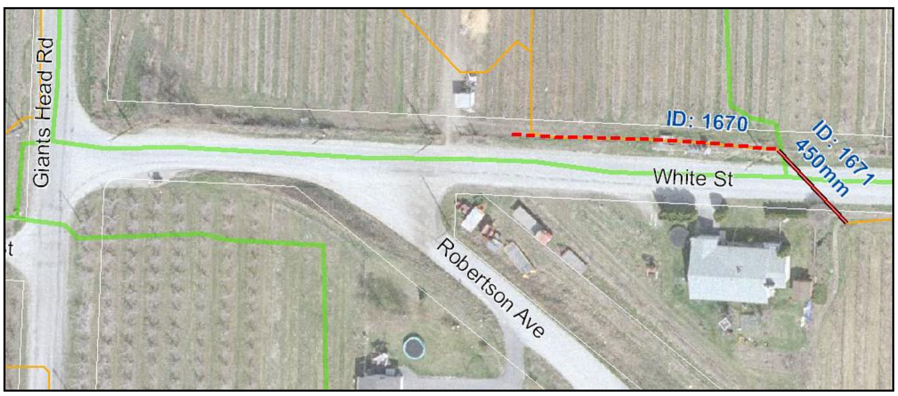
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1670	0.013	-	-	m^3/s
1671	0.013	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$26,400	$26,400	$26,400

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
Poorly defined drainage along White Street poses risk of runoff flooding private property and flowing over road.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Construct ditching along north side of White Street and a culvert across the road to the south ditch.

LID System:

There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- White Street is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: GH-04 Happy Valley Road: South of Caldwell Avenue

Priority: **3**

Trigger: Happy Valley Road upgrade, recurring flooding issues or annual capital expenditure.

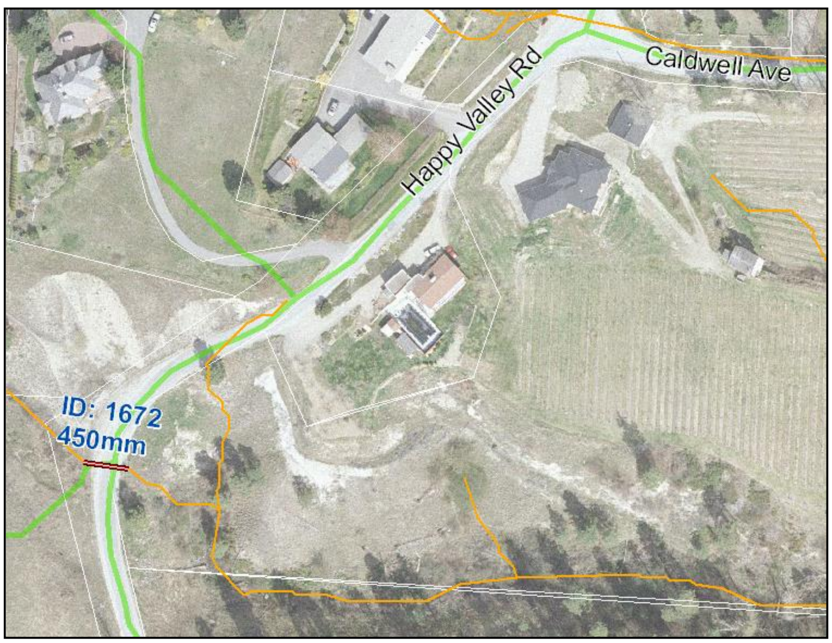
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1672	0.001	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$21,800	$21,800	$21,800

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
Runoff has previously been reported to have ponded on the west side of Happy Valley Road at the low point.

Concept:
Improve major drainage route.

Proposed Works:

Existing System:
Install a culvert across Happy Valley Road at the low point.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Happy Valley Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: GH-05 **Giants Head Road: North of Fenner Street**

Priority: **2**

Trigger: Giants Head Road upgrade or annual capital expenditure.

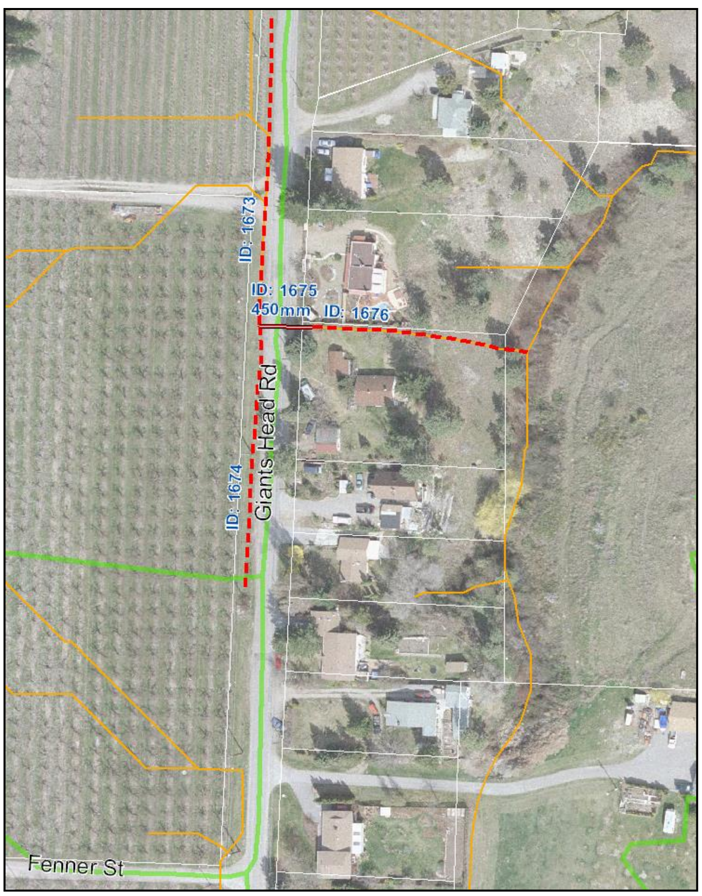
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1673	0.002	0.002	0.002	m^3/s
1674	0.023	0.023	0.023	m^3/s
1675	0.023	0.023	0.023	m^3/s
1676	0.023	0.023	0.023	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$37,500	$37,500	$37,500

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
The major draiange route along Giants Head Road is poorly defined in this area. During the July, 2007 storm, runoff from a recently stripped area intended for a vineyard crossed Giants Head Road and flowed through private property before entering the natural ravine. Significant damage occurred to the private property.

Concept:
Improve major drainage route definition and connectivity

Proposed Works:

Existing System:
Construct ditching along the west side of Giants Head Road with a culvert crossing at the low point. Install erosion-protected, landscaped swale through the private property (easement required).

LID System:
Upstream development is not anticipated to impact the proposed works, but it will benefit from them.

Conventional System:
Upstream development is not anticipated to impact the proposed works, but it will benefit from them.

Implementation:
Works should be constructed when one of the following occurs:

- Funds are available from the annual capital works budget
- Giants Head Road is upgraded
- Recurring flooding or erosion issues are reported
- Upstream development occurs

Project: GH-06 Giants Head Road: Gartrell Intersection

Priority: 2

Trigger: Giants Head Road upgrade, recurring flooding issues or annual capital expenditure.

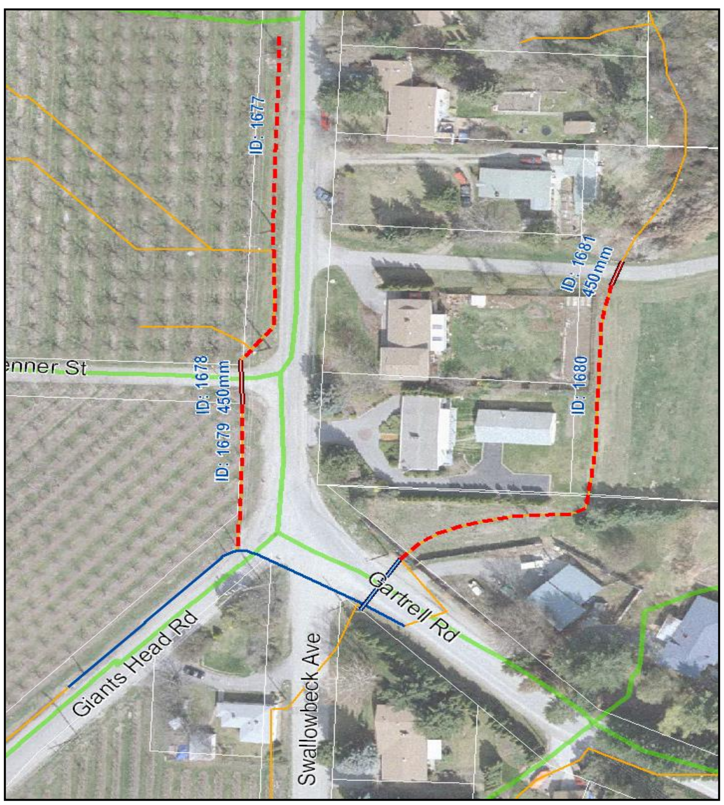
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1677	0.007	0.007	0.007	m^3/s
1678	0.008	0.008	0.008	m^3/s
1679	0.008	0.008	0.008	m^3/s
1680	0.022	0.022	0.022	m^3/s
1681	0.021	0.021	0.021	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$45,500	$45,500	$45,500

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
The major drainage route is poorly defined along Giants Head Road and Fenner Street.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Construct ditching along the west side of Giants Head Road with a culvert across Fenner Street. Obtain easement and install a swale north from Gartrell Road to the natural ravine. Install driveway culverts where necessary.

LID System:
Upstream development is not anticipated to impact the proposed works, but it will benefit from them.

Conventional System:
Upstream development is not anticipated to impact the proposed works, but it will benefit from them.

Implementation:
Works should be constructed when one of the following occurs:

- Giants Head Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget
- Upstream development occurs

Project: GH-07 **Happy Valley Road: North of Gartrell Road**

Priority: **3**

Trigger: Happy Valley Road upgrade, recurring flooding issues, or annual capital expenditure.

100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1687	0.001	-	-	m^3/s
1688	0.007	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$27,400	$27,400	$27,400

Note: *Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.*

Issue:
Poorly defined major drainage route, with marsh located on the west side of Happy Valley Road.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Construct ditching along the west side of Happy Valley Road and a culvert crossing at the low point.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Happy Valley Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: GH-08 Happy Valley Road / Gartrell Road

Priority: 2

Trigger: Recurring flooding issues or annual capital expenditure.

100 Year Design Flows:

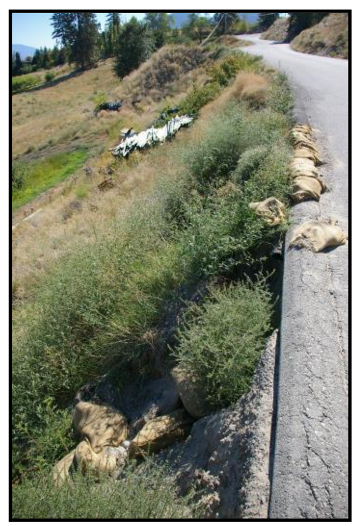
Link ID	Existing	LID	Conventional	
1682	0.002	-	-	m^3/s
1683	0.050	-	-	m^3/s
1684	0.049	-	-	m^3/s
1685	0.022	-	-	m^3/s
1686	0.004	-	-	m^3/s
1689	0.001	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$92,300	$92,300	$92,300

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:
Poorly defined major drainage along Happy Valley Road and Gartrell Road. Erosion damage occurred when runoff flowed over an asphalt curb during the July, 2007 storm.



Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Construct ditching and install culverts as shown. It might be necessary to re-grade the roads with a cross-fall to the hillside. Due to steeper grades, some form of energy dissipation works might also be required.

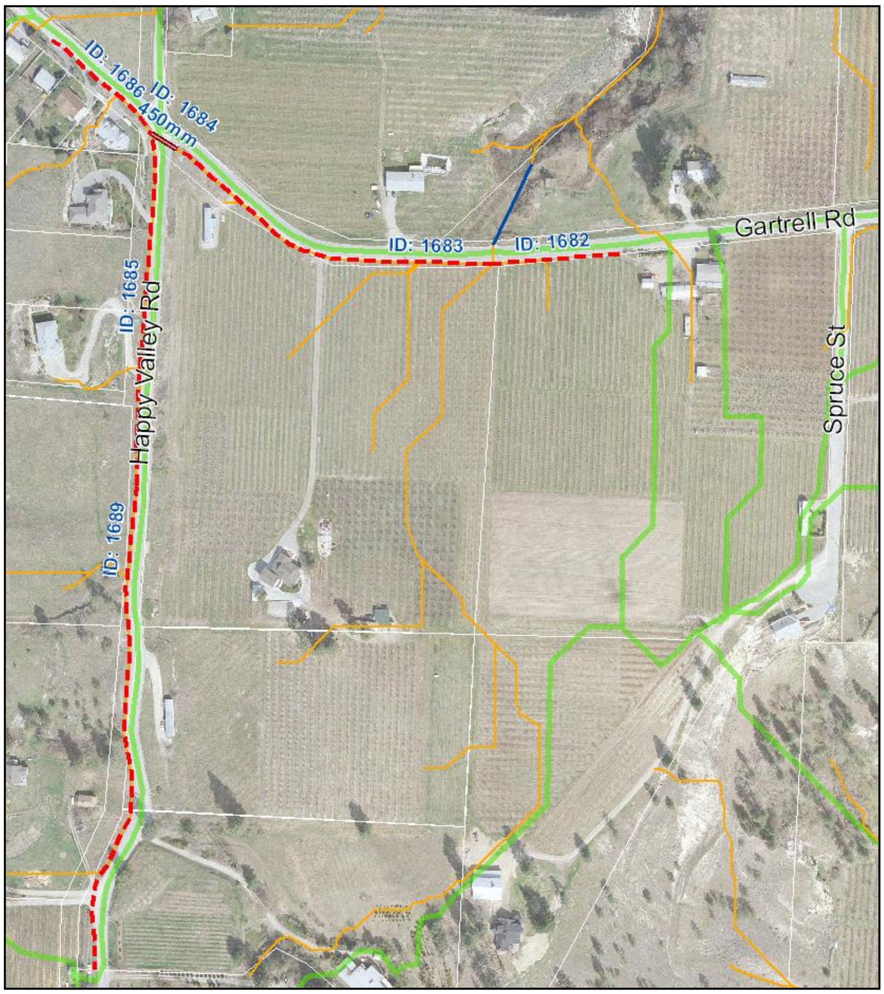
LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:

Works should be constructed when one of the following occurs:

- The subject roads are upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget



Project: GH-09 **Gartrell Road: Spruce to Kercher**

Priority: **3**

Trigger: Gartrell Road, Spruce Street or Kercher Avenue Road are upgraded, recurring flooding issues, or annual capital expenditure

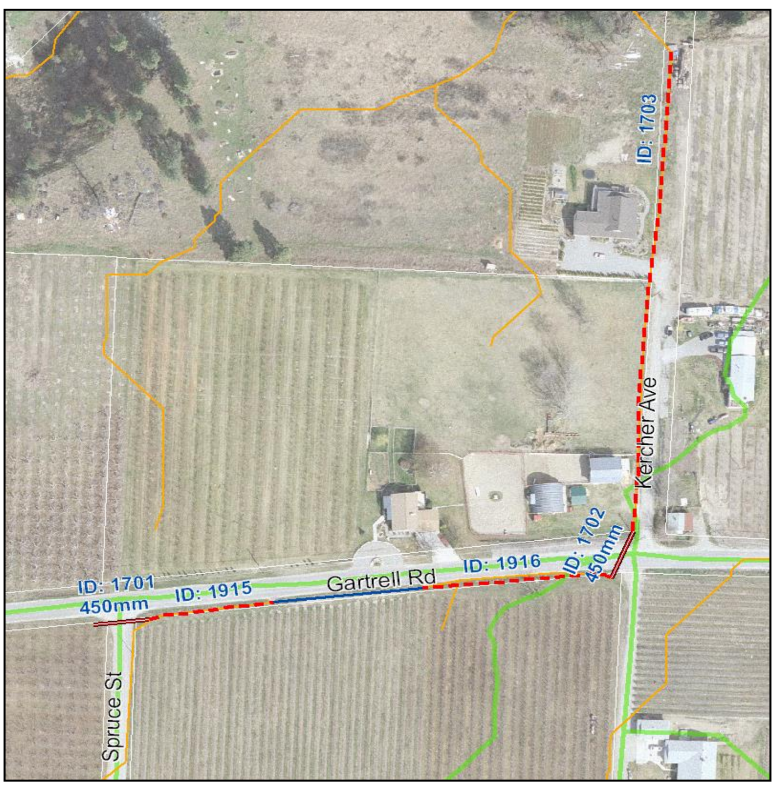
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1701	0.006	-	-	m^3/s
1702	0.026	-	-	m^3/s
1703	0.026	-	-	m^3/s
1915	0.008	-	-	m^3/s
1916	0.026	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$65,000	$65,000	$65,000

Note: *Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.*



Issue:
Poorly defined major drainage along Gartrell Road.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Install culverts across Spruce Street and Gartrell Road as indicated. Connect with ditching along south side of Gartrell Road and the west side of Kercher Avenue, following the ROW to the natural ravine.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Gartrell Road or Kercher Avenue is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

5.7 Lake Front Basin

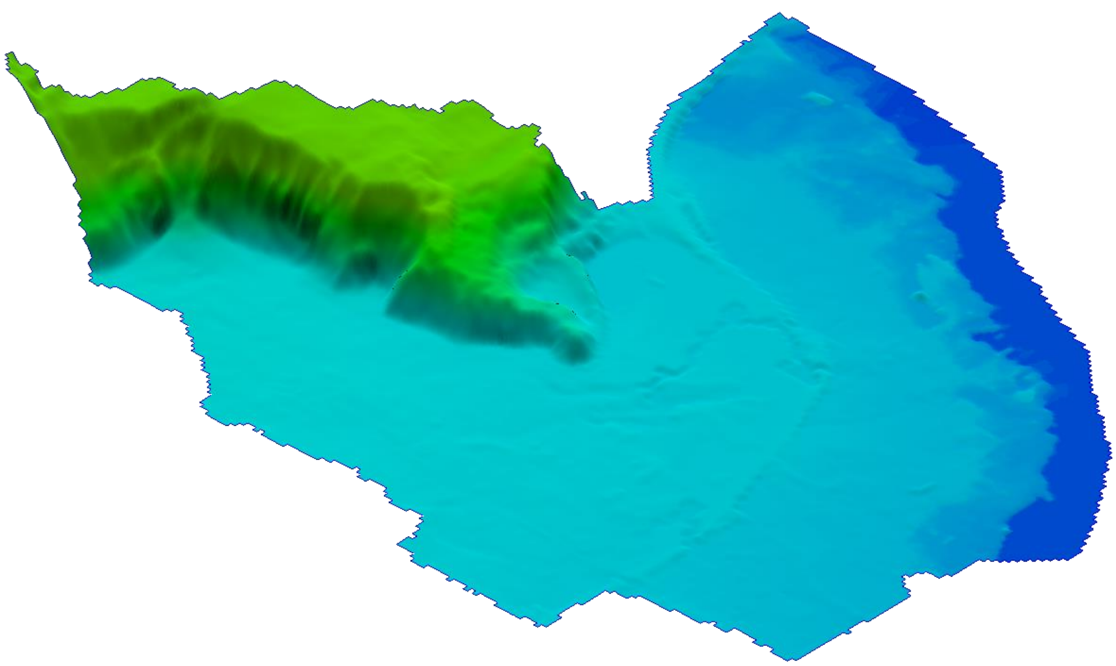
The Lake Front basin covers approximately 185 hectares and is nearly bisected by Highway 97. Except for the northwest portion, most of it is relatively flat and less than 15m above the high water level of Okanagan Lake. Lake Front Basin is not a true basin, but is rather comprised of areas which drain to Okanagan Lake via multiple small drainage routes along the shore.

5.7.1 Existing Drainage

There are no large drainage routes within this basin, and no perennial streams. Flows are dispersed over a number of swales and ditches due to the flat topography, eventually making their way down to Okanagan Lake. The area west of Highway 97 drains to a ditch along it. Two culverts provide routes across the highway, but there is no evidence that flows actually pass through them. This reflects the fact that most rainfall is absorbed by the surface soils or retained by surface depressions. The topography of the basin looking north is shown in **Figure 5.7.1**.

Except for the new road connecting both ends of Thornber Street, all the roads have rural cross sections. Despite this, there are several small piped drainage systems within the eastern portion of the basin. It is presumed that these were constructed to collect runoff from low points and transport it to the lake.

Figure 5.7.1
Topography of Lake Front Basin. Blue to green represents increasing elevation.



5.7.2 Land Use

Existing

Almost all of the lake shore has been developed into low-density residential properties. However, most of the basin is comprised of agricultural land interspersed with rural residential and pockets of low density residential development. Only the steep hillside connecting the upper bench with the lower flats remains in a natural vegetated stated.

Future

The only identified future development area is located on the east side of Highway 97. This is comprised of low-density residential on the existing RV park and along the lake shore between it and Randal Street. Construction of this development has already started.

5.7.3 Infiltration Potential

Surficial Soils

As shown in **Figure 5.7-3**, only the western half of the area west of Highway 97 within this basin has soils classified as being well to rapidly drained. The rest of the basin consists of soils classified as being poorly or moderately poorly drained.

Groundwater Conditions

There are no springs or perennial streams within the basin, and while groundwater discharge is not evident, it is assumed that the water table is not too far below the ground surface because of the influence of Okanagan Lake.

Conclusion

Except in the western half of the area on the west side of Highway 97, it is unlikely that conditions are suitable for disposing of rainfall runoff to ground. In all cases, however, a detailed site investigation should be conducted by a qualified hydro-geologist to confirm local site suitability whenever infiltration systems are proposed.

5.7.4 Analysis

This basin presents the following stormwater management challenges:

- The existence of surface depressions and a lack of well-defined drainage routes increases the risk of flooding under extreme rainfall events.
- Highway 97 creates an embankment in the middle of the basin forcing runoff to be restricted through two 600mm culverts.

- Existing residential development contributes runoff to Gartrell Road, which winds down the steep slopes of a silt bluff. During high intensity storms, runoff is concentrated on Gartrell Road and places downstream properties at risk of flooding or washouts.

Analysis indicates that:

- The rural nature of the basin results in little or no runoff from rainfall events. The exceptions are when drainage systems are adjacent to impervious areas – especially along the highway.
- In general, the existing drainage systems within the basin have sufficient capacity to accommodate what little runoff is generated.
- Existing drainage routes through private properties pose little risk as long as the rural nature of the basin remains intact.

5.7.5 Projects

Two Priority 3 projects were recommended to improve major drainage route definition and connectivity. The capital costs of both are allocated to address existing deficiencies. The remainder of this section presents the details of each proposed improvement within the basin. These can be located on **Figure 5.7-1** and examined in more detail on **Figure 5.7-P1.**

Project: LF-01 Gartrell Road: West of Arkell Road

Priority: 3

Trigger: Gartrell Road upgrade, recurring flooding issues or annual capital expenditure

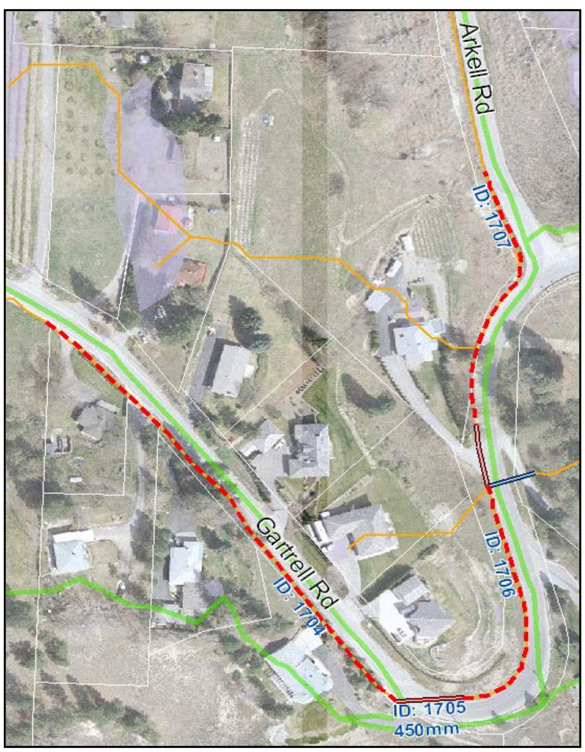
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
794	0.035	0.035	0.035	m^3/s
795	0.035	0.035	0.035	m^3/s
1704	0.027	0.027	0.027	m^3/s
1705	0.027	0.027	0.027	m^3/s
1706	0.030	0.030	0.030	m^3/s
1707	0.035	0.035	0.035	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$117,400	$117,400	$117,400

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
Poorly defined drainage route

Concept:
Improve major drainage route to allow controlled transport of runoff to downstream system.

Proposed Works:

Existing System:
Construct ditching along west side of Gartrell Road with a culvert installed at the bend to transport runoff to other side. Upgrade two existing culverts under private driveways and abandon existing culvert discharging to the east. Extend ditching along Arkell Road and connect with proposed works under Project LF-02.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Gartrell Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: LF-02 **Arkell Road: South of Hwy 97**

Priority: **3**

Trigger: Arkell Road upgrade, recurring flooding issues, LF-01, or annual capital expenditure

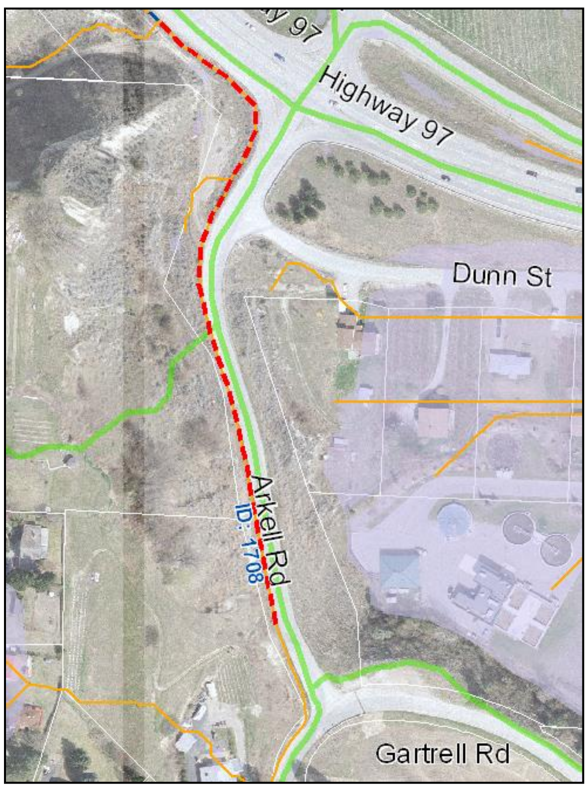
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1708	0.045	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$9,100	$9,100	$9,100

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:

Poorly defined low points along Arkell Road and lack of existing drainage infrastructure to support runoff volumes upstream from proposed works under Project LF-01.

Concept:
Define major drainage route down to existing ditching along Highway 97.

Proposed Works:

Existing System:
Construct ditching along west side of Arkell Road and along Highway 97

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Arkell Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget
- Construction of proposed works under Project LF-01

5.8 East Trout Creek Basin

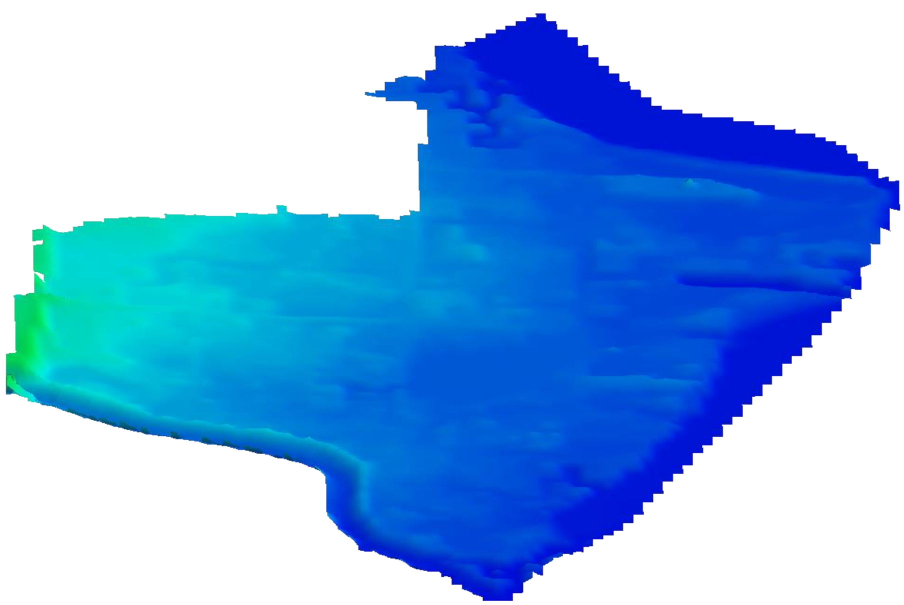
At approximately 65 hectares, the East Trout Creek basin is the smallest of the twelve within the study area. It is not a true drainage basin since it is comprised of many small drainages which would, under natural conditions, discharge directly to Okanagan Lake on the east side of Highway 97, and to Trout Creek on the west side of the highway.

5.8.1 Existing Drainage

The entire East Trout Creek basin is very flat, with a relatively constant slope of approximately 1% from west to east. The flat topography creates many small depressions which can detain runoff, increasing infiltration capacity. A levee along the north side of Trout Creek prevents direct drainage to the stream from the adjacent lands, but does form the basis of a major drainage route to a ditch on the west side of Highway 97. A series of shallow swales also drain the land to the intersection of Johnson Street and Highway 97, where the ditch ultimately directs runoff to Trout Creek.

On the east side of Highway 97, several surface drainage routes follow either rural roads or natural topography to Okanagan Lake. Many of these routes pass through private properties. There are, however, four piped systems. Three of these were, presumably, constructed to solve ponding issues at select locations. The remaining piped system (Nixon Road and Johnson Street) appears to have been constructed to service an urban road section. Dry wells are also used sparingly to handle localized drainage. The topography of the basin looking north is shown in **Figure 5.8.1**.

Figure 5.8.1
Topography of East Trout Creek Basin. Blue to green represents increasing elevation.



Trout Creek is the largest perennial creek within the District of Summerland creating a well defined drainage route to Okanagan Lake. Estimating peak flow rates and analyzing the hydraulic capacity of Trout Creek are outside the scope of this study. However, it is assumed that rainfall runoff from the study basins currently has little or no impact on Trout Creek flows.

5.8.2 Land Use

Existing

The majority of the property west of the highway is agricultural, with very little impervious surface. East of the highway is largely low density residential interspersed with vacant parcels, small agricultural plots, and parks. Roads have rural cross sections with gravel or grass shoulders allowing runoff to disperse and infiltrate.

Future

A cluster of four larger lots have been identified for future low density residential development within the area bounded by Wharf Street, Nixon Road, Johnson Street, and Highway 97. A medium-density residential development is proposed for a large parcel bounded by May Street, Johnson Street, Woods Avenue, and Okanagan Lake. It is assumed that the land within the ALR, will remain agricultural. These potential development areas can be seen in **Figure 5.8-2**.

5.8.3 Infiltration Potential

Surficial Soils

Figure 5.8-3 shows that the portion of the basin west of Highway 97 has, in general, is comprised of soils which are well to rapidly drained. On the east side of the highway, however, most of the soils are poorly to moderately drained.

Groundwater Conditions

With the presence of Okanagan Lake and Trout Creek, it is assumed that groundwater is relatively close to the ground surface. However, there are no springs, marshes, or streams to suggest any perched groundwater.

Conclusion

Use of infiltration systems to dispose of storm runoff might be suitable for small applications. In all cases, however, a detailed site investigation should be conducted by a qualified hydro-geologist to confirm local site suitability whenever infiltration systems are proposed.

5.8.4 Analysis

The primary stormwater management challenges within the East Trout Creek basin are:

- Flooding risks due to extensively flat areas with many depressions and a large proportion of impervious surfaces east of the highway.
- Drainage within the eastern half of the basin often passes through private properties. It is unlikely that the owners of these properties are aware of this condition.

Analysis indicates that:

- On the western side of the highway, surface depressions, soil storage capacity, and infiltration capacity are sufficient to capture and retain most if not all rainfall. Therefore, existing drainage facilities are considered adequate.
- On the eastern side of the highway, runoff from the impervious areas generally flows onto gravel or grassed areas resulting in no downstream discharges to the lake. The exceptions are impervious areas which discharge directly to catch basins connected to the piped systems. No capacity issues were noted under existing conditions.
- Under future development conditions, no deficiencies were noted. However, it is assumed that even if the future developments utilize conventional drainage systems, on-site measures will be implemented to attenuate post-development peak flow rates to those calculated using the unit runoff rates recommended in **Section 4.4.**

5.8.5 Projects

No specific capital works projects were recommended for the East Trout Creek Basin. It is noted, however, that none of the existing piped drainage systems are equipped with stormwater quality treatment units. Considering that collected stormwater is being discharged directly to the lake, the District should eventually install some form of treatment. It is recommended that the District budget a fixed amount each year for this purpose until all such systems discharging to the lake are equipped with adequate treatment facilities.

5.9 South Trout Creek Basin

The South Trout Creek Basin, which covers a total area of approximately 136 hectares, is comprised of areas which drain directly to Trout Creek. The topography ranges from very steep on Giants Head Mountain and along the bluffs which border Trout Creek, to relatively flat on the plateau above the bluffs.

5.9.1 Existing Drainage

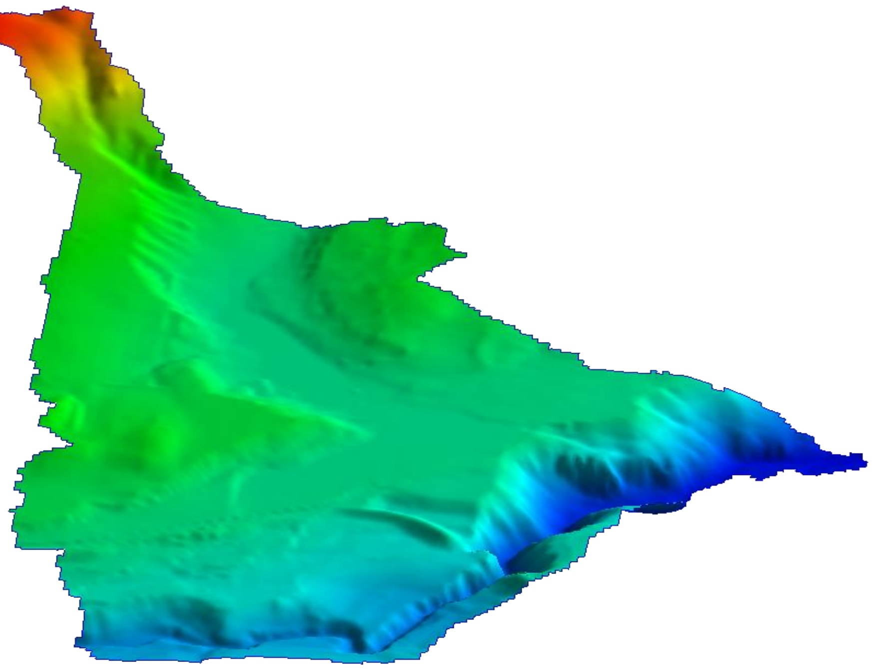
A natural spring near the base of Giants Head Mountain is the source of a perennial stream which forms the major drainage route within the basin. A ravine crossing Hillborn Street and sloping north also forms part of this drainage system. Flowing over private property, the creek enters a large depression on the west side of Giants Head Road and exits via a 300mm corrugated steel pipe that discharges into Trout Creek almost 400m to the east. The exact location, diameter, and condition of this long conduit could not be confirmed. The drainage route is heavily dependent upon the capacity of this 300mm conduit, which creates a significant flood risk should it ever be damaged or constricted.

The Kettle Valley Railway crosses through the south-western portion of the basin forming an impediment to the natural drainage courses. However, given the small amount of surface runoff generated from the rural landscape, it is assumed that whatever runoff does reach the railway, eventually seeps through or infiltrates into the ground.

Roads have rural cross sections with gravel or grass shoulders, allowing runoff to disperse and infiltrate. In addition to the pipe from Giants Head Road to Trout Creek, existing drainage infrastructure is comprised of only a few culverts and poorly-defined ditches. **Figure 5.9.1** shows the topography of the basin which predominantly sits upon a plateau above Trout Creek.

Figure 5.9.1

Topography of South Trout Creek Basin. Blue to Red represents increasing elevation.



5.9.2 Land Use

Existing

The South Trout Creek basin is comprised entirely of large agricultural parcels within the ALR. The small amount of impervious areas are comprised of the rural roads, rural residential development, and a couple of agricultural commercial sites. The steep banks of Trout Creek limit development and form a natural band at the lower reaches of the basin.

Future

Referring to **Figure 5.9-2**, a portion of a large parcel on Giants Head Mountain, identified as having low-density residential development potential, drains into the South Trout Creek basin. This site is separated from existing drainage infrastructure by both natural, undeveloped and agricultural lands.

5.9.3 Infiltration Potential

Surficial Soils

Figure 5.9-3 shows that most of the soils within the South Trout Creek basin are well to rapidly drained. Soils within the swale through which the perennial stream flows have not been classified, however it is assumed that they have poor drainage characteristics.

Groundwater Conditions

The presence of an active spring suggest that a perched groundwater table exists within the areas bordering the subsequent stream. Within the rest of the basin, however, it is assumed that the groundwater is well beneath the ground surface.

Conclusion

The area bounded by Andrew Avenue, Hillborn Street, Giants Head Road, and Giants Head Mountain, might not be suitable for infiltration systems to dispose of stormwater. The remainder of the basin, however, appears to have suitable conditions for such systems. In all cases, however, a detailed site investigation should be conducted by a qualified hydro-geologist to confirm local site suitability whenever infiltration systems are proposed.

5.9.4 Analysis

This basin presents the following stormwater management challenges:

- The 300mm corrugated steel pipe which conveys the major drainage through the catchment establishes a fixed maximum capacity. The entrance to the pipe is within a large depression and with no emergency drainage route, flooding is likely to occur should the pipe become blocked or damaged.
- The Kettle Valley Railway could function as a barrier to natural drainage since no culverts across it were located within the basin boundaries.
- Significant flows over the surface of the steep bluffs bordering Trout Creek are likely to cause erosion.

Analyses indicate that:

- In general, the combination of agricultural lands and rural road sections, complete with surface depressions, soil storage capacity, and infiltration capacity, generate little or no runoff under the design storm conditions. Therefore, no existing capacity deficiencies were noted.
- Under future development conditions, no deficiencies were noted. However, it is assumed that even if the future developments utilize conventional drainage systems, on-site measures will be implemented to attenuate post-development peak flow rates to those calculated using the unit runoff rates recommended in **Section 4.4**.

5.9.5 Projects

Six projects were recommended to improve major drainage route definition and connectivity. Of these,

- One was classified as Priority 2 because it also services future development.
- Five were classified as Priority 3.

The remainder of this section presents the details of each proposed improvement within the basin. These can be located on **Figure 5.9-1** and examined in more detail on **Figures 5.9-P1**.

Project: ST-01 Hillborn Street: Giants Head and Canyon View Intersections

Priority: **2**

Trigger: Road upgrade, upstream development, or available annual capital expenditure

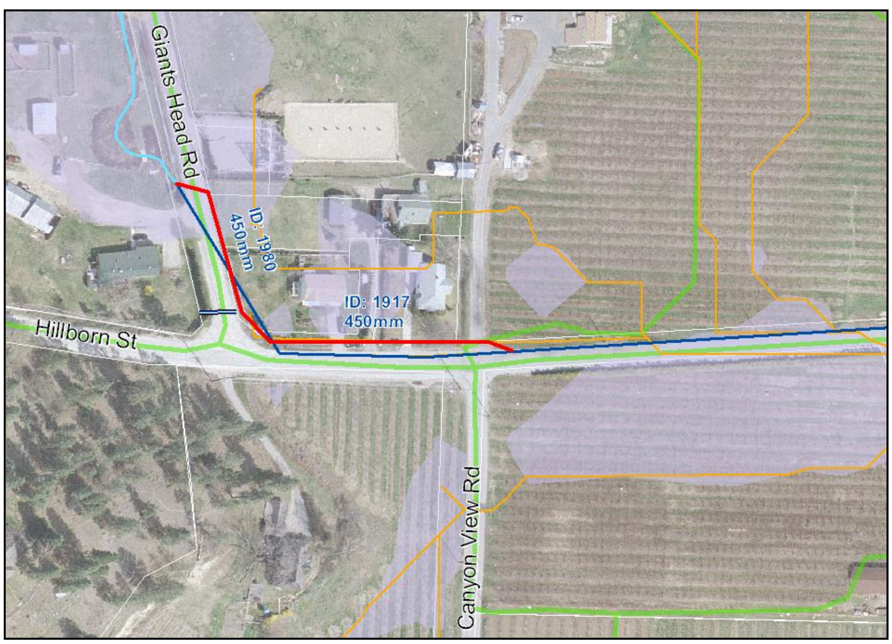
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1917	0.032	0.039	0.039	m^3/s
1980	0.032	0.039	0.039	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$94,700	$94,700	$94,700

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
There is an existing 300mm culvert on Giants Head Road which transports the perennial stream to a ravine on the south side of Hillborn Steet near the existing water reservoir. It has sufficient capacity, but appears to be in relatively poor condition. The exact alignment is also unknown, and District Staff think it might pass through the farm located at the northeast corner of the Giants Head and Hillborn intersection. Part of a proposed development on Giants Head Mountain could drain into this system, and since failure at the inlet to this system would cause flooding of the farm on both sides of Giants Head Road, provisions to upgrade this piped system should be made.

Concept:
Re-align the storm sewer to be within the road ROWs, and increase capacity of the storm sewer. Note that it is assumed that the proposed works could tie into the existing system further east on Hillborn Street. This is dependent upon the actual location of the existing pipe, which currently, is unknown.

Proposed Works:

Existing System:
Replace existing storm sewer Giants Head Road and Hillborn Street as indicated. Tie the existing culvert crossing Giants Head Road at the Hillborn intersection into the new system.

LID System:
Upstream development is not anticipated to impact the size or configuration of the proposed works, but it will benefit from them.

Conventional System:
It is assumed that the proposed development will attenuate peak flows to LID levels.

Implementation:
Works should be constructed when one of the following occurs:

- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget
- The upstream development commences. In this case, the proposed works could be constructed as part of the off-site development requirements.

Project: ST-02 Hillborn Street: West of English Avenue

Priority: 3

Trigger: Hillborn Street upgrade, recurring flooding issues, or annual capital expenditure.

100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1655	0.002	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$25,200	$25,200	$25,200

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:
Lack of drainage infrastructure from depression on south side of Hillborn Street. Risk of flooding during heavy storms.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Install culvert at the low point on Hillborn Street.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Hillborn Street is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: ST-03 Canyon View Road: West of Railroad Tracks

Priority: **3**

Trigger: Canyon View Road upgrade, recurring flooding issues, or annual capital expenditure.

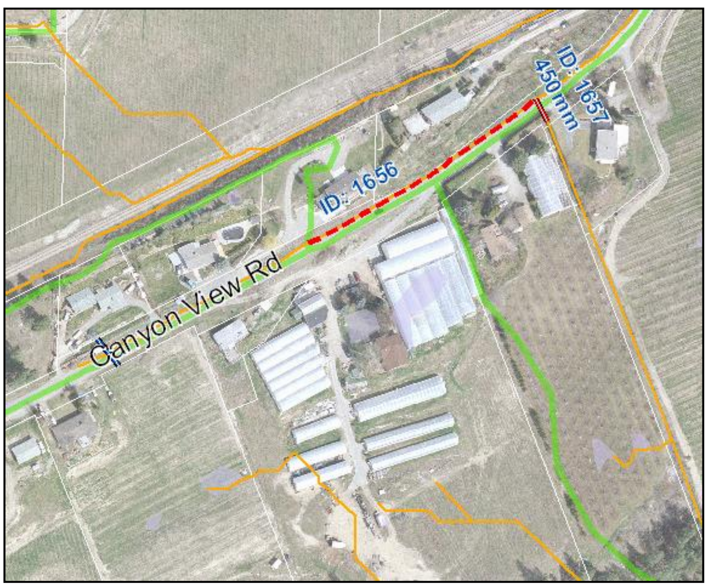
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1656	0.010	-	-	m^3/s
1657	0.015	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$24,200	$24,200	$24,200

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
Poorly defined major drainage route along Canyon View Road, posing a risk of runoff crossing the road from the north causing erosion and/or flooding.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Construct ditching along the north side of Canyon View Road and install a culvert at the low point discharging to the ravine.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Canyon View Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: ST-04 Fiske Street: East End

Priority: **3**

Trigger: Fiske Street upgrade, recurring flooding issues, or annual capital expenditure

100 Year Design Flows:

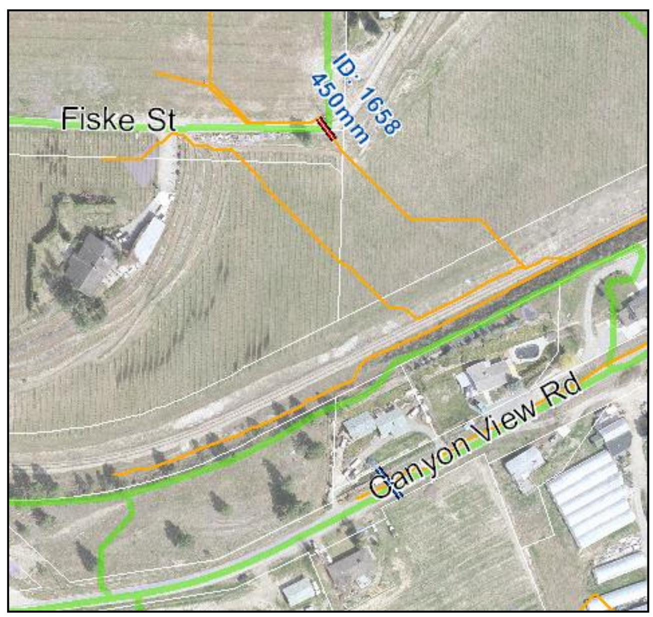
Link ID	Existing	LID	Conventional	
1658	0.004	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$20,500	$20,500	$20,500

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:
Poorly defined major drainage route at the end of Fiske Street. Runoff has previously crossed the road from the north during a heavy storm and has caused erosion.



Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Install culvert across Fiske Street at low point.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Fiske Street is upgraded
- Recurring flooding or erosion issues are reported

- Funds are available from the annual capital works budget

Project: ST-05 Giants Head Road: Between Gartrell and Hillborn

Priority: 3

Trigger: Giants Head Road upgrade, recurring flooding issues or annual capital expenditure.

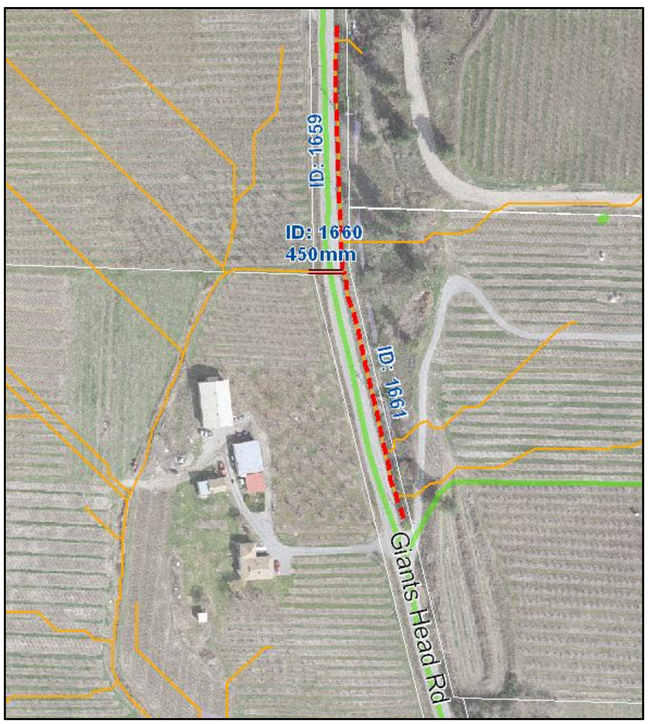
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1659	0.010	-	-	m^3/s
1660	0.015	-	-	m^3/s
1661	0.005	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$27,400	$27,400	$27,400

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
Poorly defined major drainage route along Giants Head Road posing risk of runoff crossing road from the east and causing erosion and/or flooding.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Construct ditching along east side of Giants Head Road and install a culvert at the low point discharging to the west.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Giants Head Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: ST-06 Giants Head Road: North of Hillborn

Priority: 3

Trigger: Giants Head Road upgrade, recurring flooding issues or annual capital expenditure.

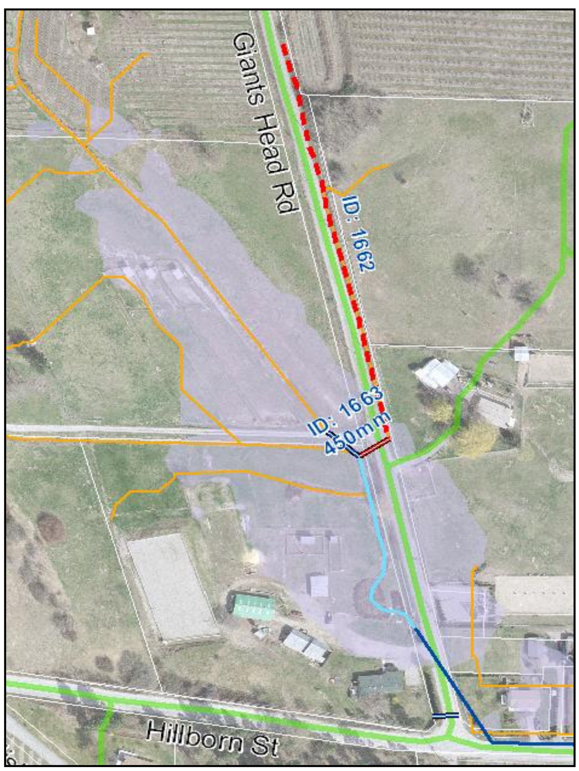
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1662	0.010	-	-	m^3/s
1663	0.011	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$29,000	$29,000	$29,000

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
Poorly defined major drainage along Giants Head Road posing risk of runoff crossing the road from the east and causing erosion and/or flooding.

Concept:
Define major drainage route along Giants Head Road.

Proposed Works:

Existing System:
Construct ditching along east side of Giants Head Road and install a culvert at the low point discharging into the stream. Alternatively, if Project ST-01 is constructed, tie the ditch into the new storm sewer rather than constructing the culvert across Giants Head Road.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Giants Head Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

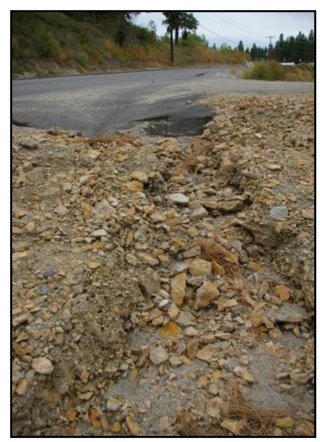
5.10 Kevin Brook Basin

Kevin Brook Basin covers approximately 515 hectares, and is a true basin because of the perennial stream flowing through it to Trout Creek.

5.10.1 Existing Drainage

Kevin Brook forms the predominant drainage route for the basin, and its source is a spring near the intersection of Gilman and Simpson Roads. The natural ravine through which this stream flows is well defined, but has been encroached-upon by residential development as it rounds the north-east portion of the hill between Simpson Road and South Victoria Road. Ultimately, the stream crosses under the Kettle Valley Railway via large-diameter culverts and heads south following the railway. It also crosses Canyon View Road onto private property. It appears that the natural channel on the property south of Canyon View Road has been filled-in for agricultural purposes. Since the stream has a perennial flow, it is assumed that a pipe was installed to accomplish this. The location and size of the pipe was not confirmed because it is located on private property. Ultimately, Kevin Brook discharges to Trout Creek.

Most of the existing piped drainage systems service a combination of industrial and residential development in the northern portion of the basin. These drainage systems are tributary to a storm sewer along South Victoria Road which discharges into Kevin Brook. There is a significant amount of impervious area within these sub-catchments, but much of it is not directly connected to the drainage systems because only some of the roads have curb & gutter with catch basins. Drywells are sometimes used at low points in the roads where necessary.

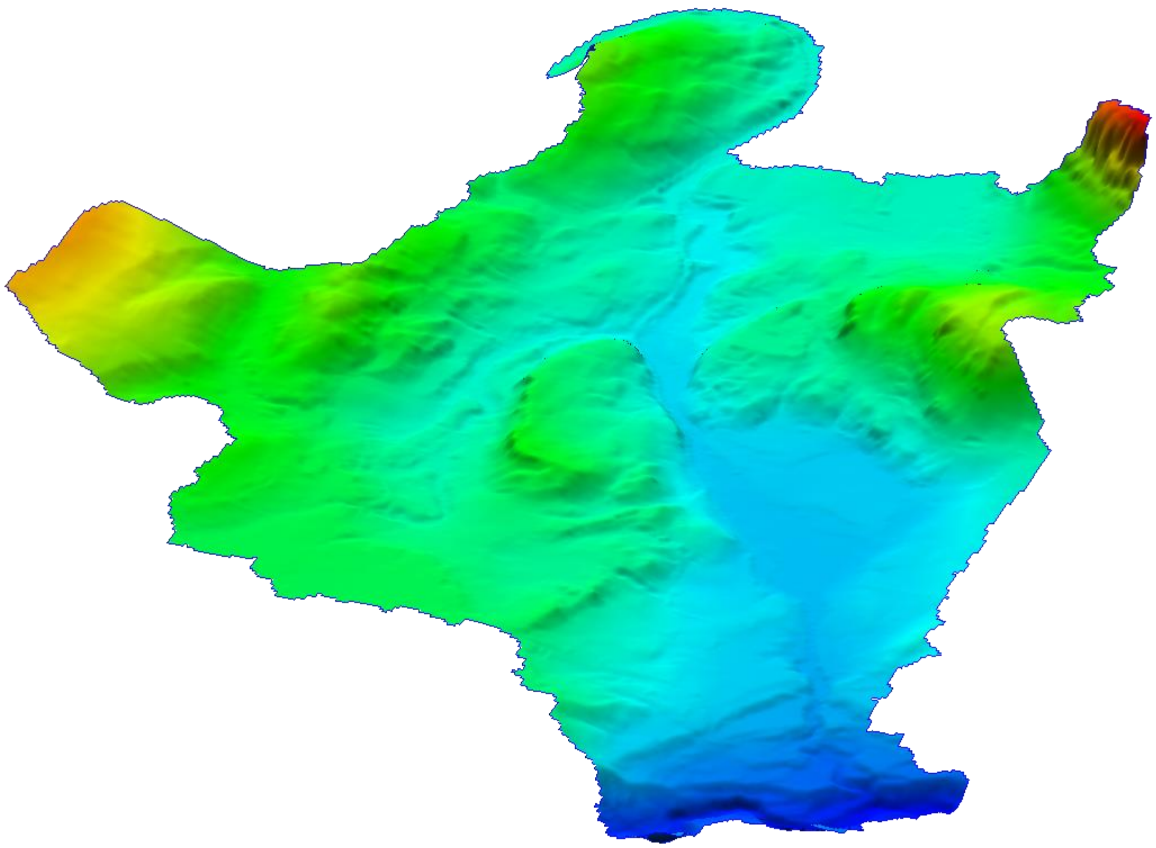


Most roads have rural cross sections, but asphalt curbs have been constructed along select sections to managed runoff where drainage complaints have occurred. Because these asphalt curbs are sometimes quite long, without any discharge locations except at the downstream end, they concentrate runoff and sometimes cause downstream problems. One example is Simpson Road, where discharges to the ditch have cause erosion on the road shoulder. Another example is along South Victoria Road within the section that passes through the low density residential development. During the July, 2007 rainfall event, concentrated runoff which reached the end of the asphalt curb could not enter the flat catch basin, and followed the existing topography onto private land.

The basin boundaries include a hill which is traversed by the Kettle Valley Railway. No culverts across the railway were located in this area, so technically, all runoff from the hill would be re-directed by the railway to the intersection of Simpson Road and South Victoria Road.

Figure 5.10.1 shows the topography of the Kevin Brook Basin, looking northwest. The basin drains into Trout Creek located in the dark blue area shown.

Figure 5.10.1
Topography of Kevin Brook Basin. Blue to Red represents increasing elevation.



5.10.2 Land Use

Existing

In general, the Kevin Brook Basin consists of undeveloped natural landscape, agricultural land, and rural residential development. An industrial park exists between the Kettle Valley Railway and Giants Head Mountain consisting of large warehouses, graveled parking / storage areas, and rural-section roads. Most of the low-density residential development within this basin is also located in this area and along the northern part of South Victoria Road. The Canyon View Cemetery is located in the south western corner of the basin at the intersection of Simpson and Canyon View Road.

Future

A significant number of large parcels within this basin have been identified for potential development as shown in **Figure 5.10-2**. These are predominantly a mixture of low and medium density residential housing. The largest proposed development, Jersey Lands, is located on the western slope of the Kevin Brook Basin and spans into the neighboring Prairie Creek and West Trout Creek basins. The rest of the developments, are individually smaller, but collectively, have the potential to significantly impact flows within Kevin Brook.

It is assumed that all land currently within the ALR will remain agricultural.

5.10.3 Infiltration Potential

Surficial Soils

Most of the soils located on the steeper slopes of the mountains within the basin have not be classified with respect to drainage characteristics. As shown in **Figure 5.10-3** however, most of the soils which have been classified, are well to rapidly drained. The exception is within the existing industrial and residential development areas located in the northern part of the basin. These soils have been classified as being moderately to well drained.

Groundwater Conditions

In addition to the perennial flow within Kevin Brook, this natural drainage corridor contains several wetlands where topography is relatively flat. Marshy areas were also noted along Bennett, Lewis, and Sage Avenues. Considering that the soils within these areas have been classified has being well to rapidly drained, one must assume that there are pockets of perched groundwater through the basin.

Conclusion

In general, most areas within the basin appear to be suitable for the use of infiltration systems to dispose of stormwater. However, caution should be exercised within the northern portion of the basin and where perched groundwater may exist. In all cases, a detailed site investigation should be conducted by a qualified hydro-geologist to confirm local site suitability whenever infiltration systems are proposed.

5.10.4 Analysis

This basin presents the following stormwater management challenges:

- Kevin Brook forms the major drainage route for this basin. Since a substantial amount of development has been projected, there is also significant potential for high flows to be discharged to this stream. This could result in the need for substantial upgrades to the channel section and culvert sizing. Such upgrades would cause significant damage to the environmental and habitat values which currently exist.
- The storm sewer system in the industrial park and residential area directly connects surface runoff from roads with curb and gutter, reducing infiltration opportunities and increasing flows to Kevin Brook. This condition would be exacerbated by further conversion of roads from rural to urban cross sections.

- The Kettle Valley Railway bisects the Kevin Brook Basin, acting as an impediment to surface runoff. Ditches along the railway direct flows along the railway to culverts installed at select locations. This establishes a fixed capacity at each location and alters the natural drainage path.

Analyses indicate that:

- In general, most if not all runoff generated from rainfall events under existing conditions, enters Kevin Brook from the piped drainage systems tributary to the system on South Victoria Road. However, no existing capacity deficiencies were noted.
- Most if not all of the rainfall within the natural and agricultural areas within the basin is captured and retained within the surface soil layer, contributing little or no runoff to Kevin Brook.
- Future development employing LID methods for stormwater management, results in negligible increases to the Kevin Brook flow rates. Therefore, no improvements to and within Kevin Brook were required under this scenario.
- Future development employing conventional drainage methods generated very high flow rates which would have a significant impact on Kevin Brook. Rather than proposing works within or along this stream to mitigate these impacts, it is recommended that on-site measures be implemented to attenuate post-development peak flow rates to those calculated using the unit runoff rates recommended in **Section 4.4**.

5.10.5 Projects

Ten projects were identified for this basin – four Priority 2, and six Priority 3. All except one of the Priority 2 projects are entirely required to service future development – Project KB-07 also addresses a minor existing deficiency. The Priority 3 projects address were recommended to improve major drainage route definition and connectivity.

All of the projects can be located on **Figure 5.10-1**. Detailed descriptions of each project are provided within the remainder of this section. Refer to **Figures 5.10-P1** to **5.10-P3** for additional context.

Project: KB-01 **Monroe Avenue: North of Canyon View Road**

Priority: **3**

Trigger: Monroe Avenue upgrade, recurring flooding issues, or annual capital expenditure

100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1609	0.014	-	-	m^3/s
1610	0.002	-	-	m^3/s
1611	0.009	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$31,400	$31,400	$31,400

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:
Poorly defined major drainage posing a risk of flooding and runoff crossing Monroe Avenue.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Construct ditching along west side of Monroe Avenue with a culvert discharging to the east side at the low point.

LID System:
No upstream development is anticipated.

Conventional System:
No upstream development is anticipated.

Implementation:

Works should be constructed when one of the following occurs:

- Monroe Avenue is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: KB-02 Monroe Avenue: South of Railway Tracks

Priority: **3**

Trigger: Monroe Avenue upgrade, recurring flooding issues or annual capital expenditure

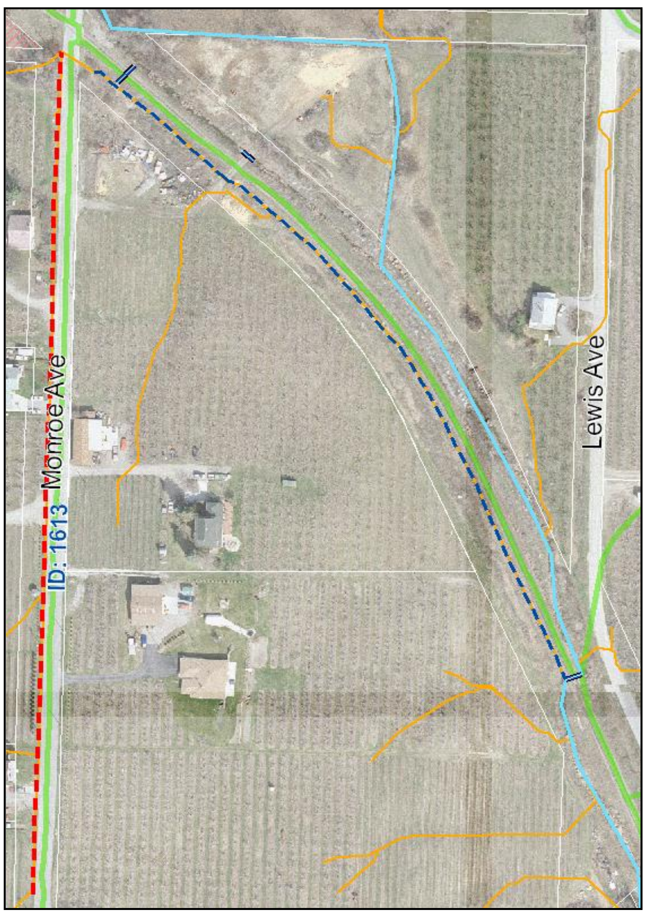
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1613	0.021	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$30,300	$30,300	$30,300

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
Poorly defined major drainage along Monroe Avenue.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Install a ditch along the west side of Monroe Avenue, draining north to the low point at the Kettle Valley Railroad.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Monroe is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

This project requires the culvert proposed under Project KB-03 to be installed first.

Project: KB-03 Gilman Road: Extension Eastward to Monroe Avenue

Priority: 2

Trigger: Development on Victoria Hill, flooding issues to the west of Monroe Avenue.

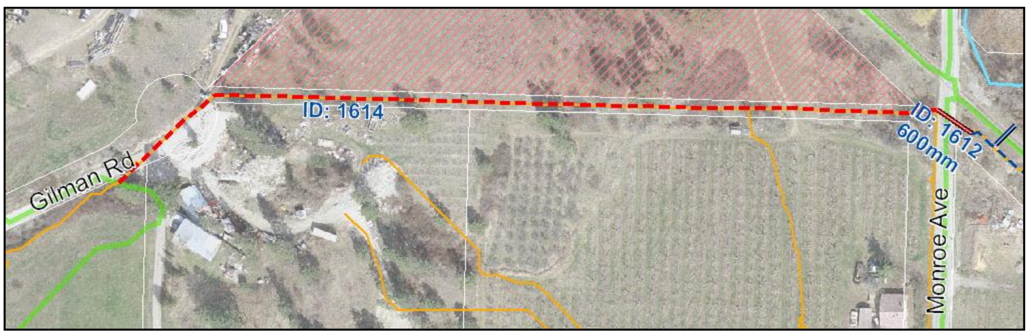
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1612	-	0.025	0.277	m^3/s
1614	-	0.010	0.008	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$0	$58,900	$60,100

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
There is no well-defined drainage route from the end of Gilman Road, nor is one available for potential runoff from upstream development.

Concept:
Define major drainage route between Gilman Road and Monroe Avenue.

Proposed Works:

Existing System:
No existing deficiencies are noted.

LID System:
Construct ditching from the end of Gilman Road, down the easement to Monroe Avenue, and install a culvert to the existing ditch on south side of the Kettle Valley Railway. Install driveway culverts as required.

Conventional System:
Capacity in the receiving drainage system allows for conventional flows from the future development to be discharged without attenuation. (This applies only to the 100 year conditions – minor system flows would require attenuation as per those proposed in **Section 4.4** since these occur relatively frequently.) The topography of the site allows for runoff to be collected and discharged into a culvert under Monroe Road. This poses a significantly higher flow than under LID conditions, requiring a larger diameter culvert and hence greater capital cost.

Implementation:

- If the future development implements LID methods, require the proposed works as off-site works to be constructed by the Developer using the culvert sizing associated with the LID analysis.
- If the future development uses conventional drainage, require the proposed works as off-site works to be constructed by the Developer using the culvert sizing associated with the Conventional analysis.
- If construction of project KB-02 is required prior to this project, at least the culvert under Monroe Avenue must be constructed.

Project: KB-04 **Simpson Road: From Jersey Lands**

Priority: **2**

Trigger: Jersey Lands development.

100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1631	-	0.020	0.442	m^3/s
1632	-	0.002	0.394	m^3/s
1634	-	0.060	0.440	m^3/s
1635	-	0.058	0.437	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
-	$145,900	$148,400

Note: *Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.*

Issue:

The Jersey Lands development will require defined major drainage routes to Kevin Brook since it is separated from the stream by private property.

Concept:
Define major drainage route between proposed development and Simpson Road

Proposed Works:

Existing System:
No existing deficiencies are noted.

LID System:
Construct ditching along the existing easement to Simpson Road, and install a culvert. Continue ditching north along east side of Simpson Road (the west side of the road is constructed on fill, and cannot accommodate a ditch) with culvert at the low point to discharge into the existing ditch on west side.

Conventional System:
Due to the extent of the Jersey Lands development the discharge volumes from a conventional system present substantially larger flows than from LID conditions. This would require not only culverts to be upsized accordingly, but would also require significant works to protect the stream from erosion. These downstream works would likely consist of either linear detention ponds or a bypass storm sewer since widening and armoring the stream would not be environmentally acceptable. All of this would result in increased capital costs that are not considered feasible. Therefore, it is recommended that sufficient runoff attenuation be implemented on-site to limit discharge rates to those under LID conditions. Consequently, the proposed works for the Conventional System scenario are the same as those for the LID scenario.

Implementation:
Require these works to be constructed as part of the off-site development requirements.

Project: KB-05 **Simpson Road: North of Gilman Road**

Priority: **3**

Trigger: Simpson Road upgrade, recurring flooding issues, or annual capital expenditure

100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1633	0.002	-	-	m^3/s
1636	0.036	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$21,100	$21,100	$21,100

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:

Poorly defined major drainage route along Simpson Road, approximately 200 m north of the Gilman Road intersection.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Install a culvert across Simpson Road and construct ditching north to connect with the proposed Project KB-06 works.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Simpson Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Note that the proposed project KB-06 works must be completed first.

Project: KB-06 Simpson Road: South of Fyffe Road

Priority: **3**

Trigger: Simpson Road upgrade, recurring flooding issues or annual capital expenditure

100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1637	0.012	-	-	m^3/s
1638	0.002	-	-	m^3/s
1639	0.013	-	-	m^3/s
1640	0.013	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$37,700	$37,700	$37,700

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:
Poorly defined major drainage along Simpson Road poses risk of runoff crossing the road from the west and causing damage to private property.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Construct ditching along the west side of Simpson Road to a culvert at the low point. Obtain an easement and construct a grassed swale along the property line to the east until it reaches the existing ravine.

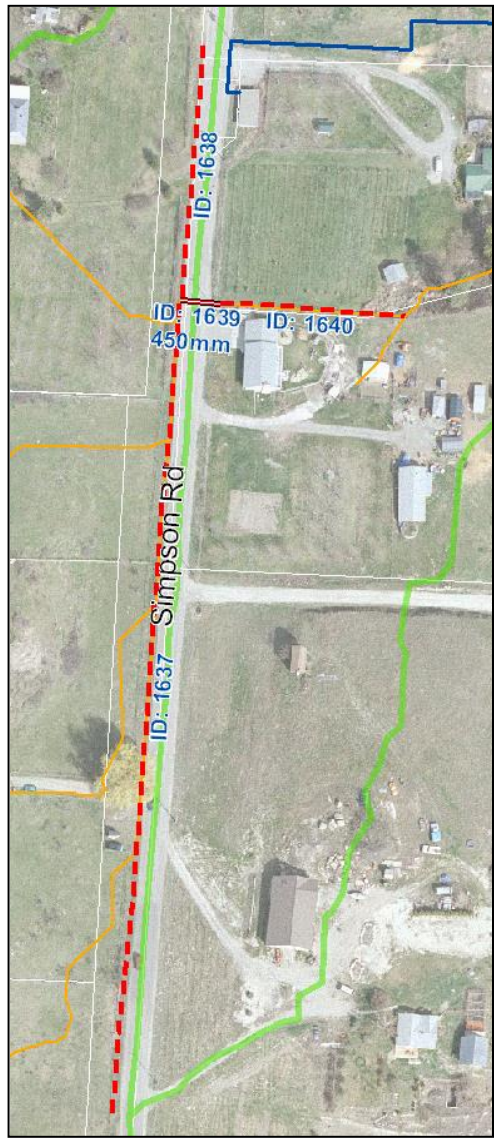
LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:

Works should be constructed when one of the following occurs:

- Simpson Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget



Project: KB-07 South Victoria Road and Monroe Avenue

Priority: 2

Trigger: Upstream development, South Victoria Road upgrade, recurring flooding issues, or available annual capital expenditure funds

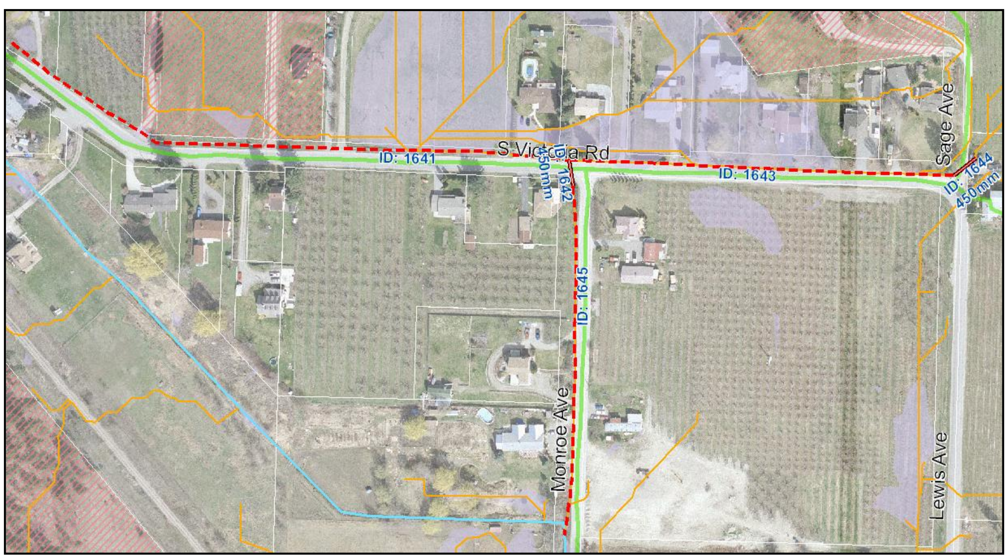
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1641	0.018	0.018	0.018	m^3/s
1642	0.018	0.018	0.066	m^3/s
1643	0.011	0.011	0.105	m^3/s
1644	0.001	0.001	0.001	m^3/s
1645	0.019	0.019	0.068	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$151,800	$151,800	$151,800

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
A significant amount of future development is projected to occur north of South Victoria Road. Note that there is an existing depression created by the road into which potential runoff from the developments could flow. This increases the risk of flooding for the subject properties.

Concept:
Improve major drainage definition and connectivity by providing a means of draining the existing depression.

Proposed Works:

Existing System:
Construct ditching along north side of South Victoria Road and down the west side of Monroe Avenue. Install culverts across South Victoria Road and Sage Avenue.

LID System:
The discharge rates under LID conditions remain unchanged from existing conditions therefore the proposed works remain the same.

Conventional System:
The culvert sizing under conventional system conditions would be larger, so the costs would be higher.

Implementation:

These works would address an existing deficiency as well as service future development. For the purposes of this study, it has been assumed that the works would not be required until development occurs. Therefore, these works would be part of the required off-site improvements.

Project: KB-08 **South Victoria Road: North of Sedona Heights**

Priority: **3**

Trigger: Road upgrade, recurring flooding, or when funds are available from the annual capital expenditure plan

100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1646	0.017	-	-	m^3/s
1647	0.004	-	-	m^3/s
1974	0.022	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$45,700	$45,700	$45,700

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:
Poorly defined major drainage along South Victoria Road poses risk to runoff crossing the road from the east and causing damage to private property.

Concept:
Improve major drainage route definition and connectivity to Kevin Brook.

Proposed Works:

Existing System:
Construct ditching along the east side of South Victoria Road and install a culvert at the low point, discharging into Kevin Brook.

LID System:
There is no anticipated development upstream of the proposed works.

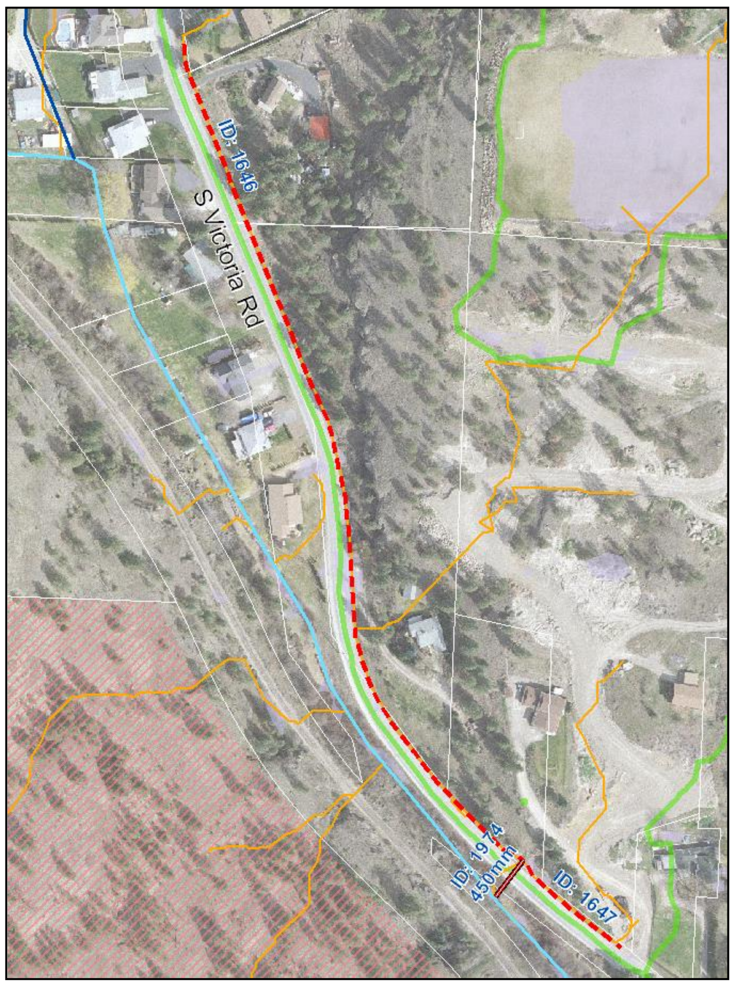
Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:

Works should be constructed when one of the following occurs:

- South Victoria Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Note that this project overlaps with Project KB-10. Much depends on the timing of these two projects. If KB-10 is anticipated to be constructed in the near future, then the limits of Project KB-08 could be reduced significantly. However, if KB-10 is not anticipated for several years, and one of the triggers for this project occurs, then is should be constructed as proposed.



Project: KB-09 Simpson Road at South Victoria Road

Priority: **3**

Trigger: Simpson Road upgrade, recurring flooding issues or annual capital expenditure

100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1648	0.002	-	-	m^3/s
1649	0.001	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$39,800	$39,800	$39,800

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:

As the Kettle Valley Railway traverses a large hill to the northwest of the subject location, it also intercepts runoff and directs it to this intersection. Currently, there is no infrastructure to provide a formal drainage route.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Install culverts across Simpson Road and Kettle Valley Railway

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when proposed works under KB-10 have been completed and either:

- Simpson Road is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Note that when Project KB-10 is completed, it might be necessary to connect these culverts to the proposed storm sewer system on South Victoria Road.

Project: KB-10 South Victoria Road: Simpson Road to Kevin Brook

Priority: **2**

Trigger: Upstream development between South Victoria Road and Cedar Avenue.

100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1650	-	0.040	0.040	m^3/s
1651	-	0.039	0.039	m^3/s
1973	-	0.035	0.162	m^3/s
1975	-	0.035	0.162	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
-	$401,700	$401,700

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:
The existing drainage along South Victoria Road is provided by a 250 storm sewer. Currently, this is sufficient for existing development conditions, but can provide capacity for only the minor system flows anticipated from upstream development. The road is the only surface major drainage route for this area, but it is graded such that runoff will enter private property rather than stay on the road until it is past the existing residential development. It does not have the capacity to function as the major drainage route under future development conditions.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

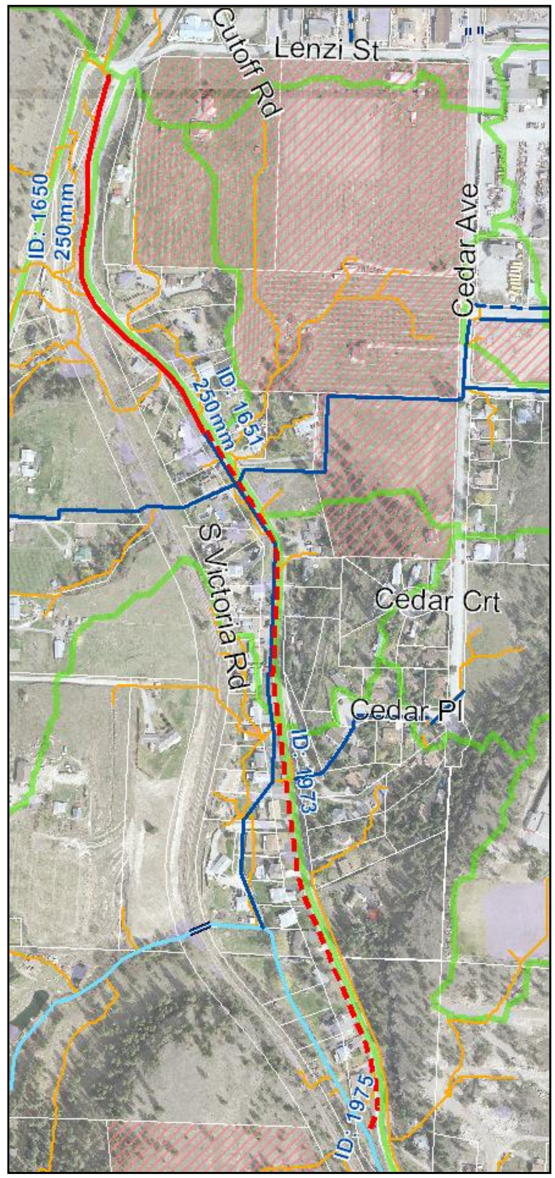
Existing System:
No existing deficiencies are noted.

LID System:
Urbanize South Victoria Road by installing curb and gutter from the Simpson Road intersection to where a let-down can be constructed to Kevin Brook. This will require installation of side-inlet catch basins and leads to the existing storm sewer.

Conventional System:
The higher design flows under the conventional conditions are given only for information purposes. It is recommended that the development upstream of this project attenuate runoff discharge rates to match those anticipated under LID conditions. Therefore, the infrastructure sizing and associated capital costs will remain unchanged.

Implementation:
The works proposed in this project should be included as part of the off-site requirements for the upstream developments. If there are more than one Developer, it might be necessary for the District to either:

- Collect DCCs to fund this project so that the cost is shared by all, or
- Be prepared to develop a later-comer agreement so that the first Developer to construct can recover the associated costs.



5.11 West Trout Creek Basin

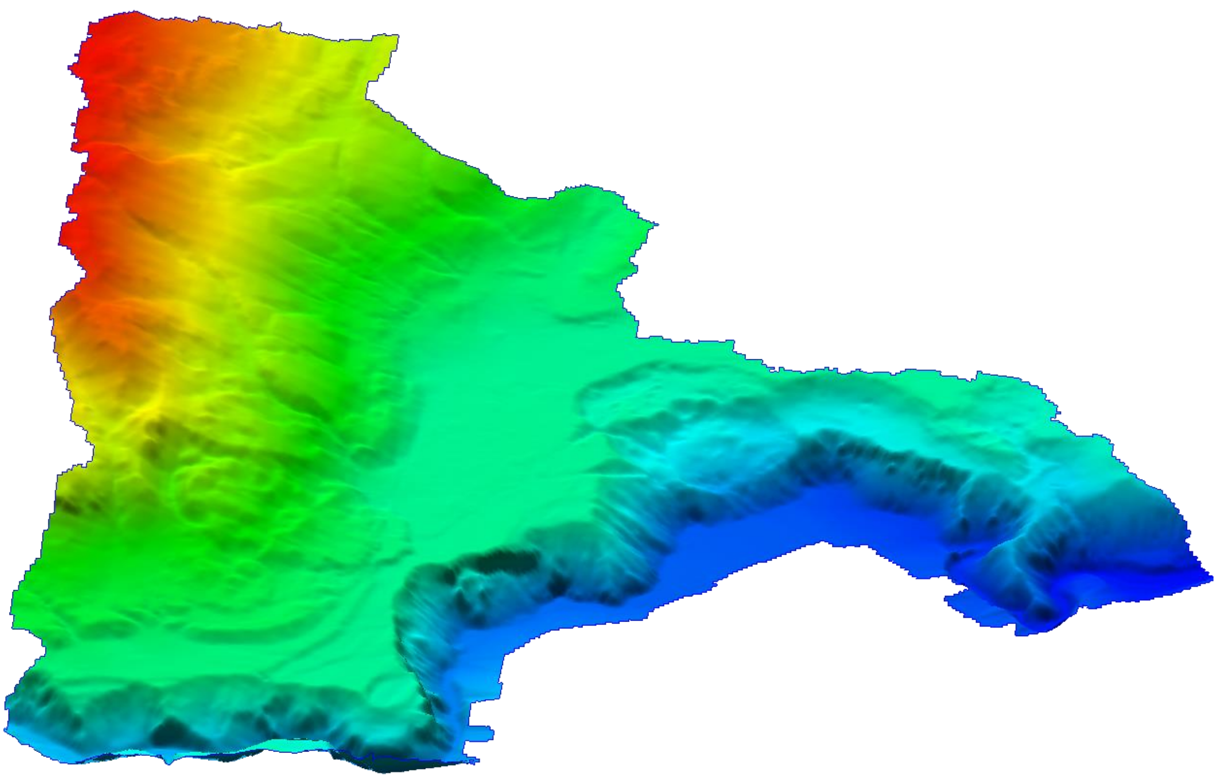
The West Trout Creek Basin, with an area of approximately 400 hectares, is not a true drainage basin. It is a collection of small catchments which drain directly to Trout Creek.

5.11.1 Existing Drainage

The only existing drainage infrastructure within this basin are a few drywells. All of the roads have rural cross sections, and surface drainage routes follow the natural topography. To date, this has not caused any significant problems because most if not all rainfall is captured and retained by surface soils.

Approximately half of the basin consists of relatively steep hillsides to the west, and steep bluffs bordering Trout Creek. A small area within the plateau above the bluffs is relatively flat. **Figure 5.11.1** shows the topography of the West Trout Creek Basin looking north.

Figure 5.11.1
Topography of West Trout Creek Basin. Blue to red represents increasing elevation.



5.11.2 Land Use

Existing

Most of the basin consists of natural landscape – sparsely distributed pine trees and tuft grass. These are located mainly on the steeper hillside and along the bluffs above Trout Creek. The Summerland Golf & Country Club is the major development, and covers most of the flatter plateau area. The rest of the basin consists of agricultural land and rural residential development. The steep slopes of Trout Creek Canyon preclude any uses other than preservation and perhaps recreation.

Future

Referring to **Figure 5.11-2**, three development areas have been identified within the West Trout Creek Basin. The largest consists of the southern portion of the Jersey Lands development. It is likely to be accessed via Mountain Avenue, which would also function as one of the primary drainage routes. Being a combination of low and medium density residential, the development would replace existing natural landscape and increase the amount of impervious area. The second development area is located to the west of the golf course, and is anticipated to be low to medium density residential also. Part of this site borders the bluffs leading down to Trout Creek, so stormwater management must ensure the bluffs are protected from erosion. The District owns a parcel south of Canyon View Road which is also proposed for residential development. This area drains directly over the bluffs to Trout Creek, so on-site drainage works must also include measures to prevent erosion.

5.11.3 Infiltration Potential

Surficial Soils

Referring to **Figure 5.11-3**, only the soils within the plateau area have been classified with respect to drainage characteristics. In general, these soils are well to rapidly drained. On the hillside to the west, it is assumed that there are more occurrences of shallow or exposed bedrock, and there have moderate to low drainage characteristics. The bluffs along Trout Creek appear to consist of silts, and therefore are assumed to be poorly drained.

Groundwater Conditions

Except for a couple of water hazards on the golf course, no springs, perennial streams, nor wetlands have been identified. It is therefore assumed that the groundwater table is well below the ground surface.

Conclusion

It appears that conditions within the plateau area are suitable for using infiltration systems to dispose of stormwater. Additional information is required before an assessment can be made regarding the western hillside. Caution should be used when contemplating any infiltration systems near the top of the silt bluffs bordering Trout Creek. In all cases, a detailed site investigation should be conducted by a qualified hydro-geologist to confirm local site suitability whenever infiltration systems are proposed.

5.11.4 Analysis

This basin presents the following stormwater management challenges:

- There is a lack of existing drainage infrastructure downstream of proposed developments.
- Proposed development within the upper reaches of the basin are expected to generate runoff through existing drainage routes which to date, have remained essentially dry.
- Development along the steep bluffs has the potential to generate runoff which could cause soil erosion.

Analyses indicate that:

- The combination of existing land use and natural drainage patterns have worked effectively to date, capturing and retaining most if not all rainfall.
- Even under LID development conditions, sufficient surface runoff is generated to require construction of some downstream drainage works.
- While the hydraulic capacity of the downstream works necessary to service development implementing LID methods is sufficient to accommodate peak flows from development using conventional drainage methods, the concern is that these flows would cause significant erosion within constructed and natural channels. Therefore, it is recommended that on-site measures be implemented to attenuate post-development peak flow rates to those calculated using the unit runoff rates recommended in **Section 4.4**.

5.11.5 Projects

Only two projects were identified for this basin – one was assigned a Priority 2 while the other was assigned a Priority 3. Both consist of improving major drainage route definition and connectivity, but the Priority 2 project, WT-02, also services future development on Jersey Lands. These projects can be located on **Figure 5.11-1** with additional context and details found on **Figure 5.11-P1**.
Detailed descriptions of each project are provided within the remainder of this section.

Project: WT-01 Canyon View Road: East of Paradise Road

Priority: **3**

Trigger: Canyon View Road upgrade, recurring flooding issues or annual capital expenditure.

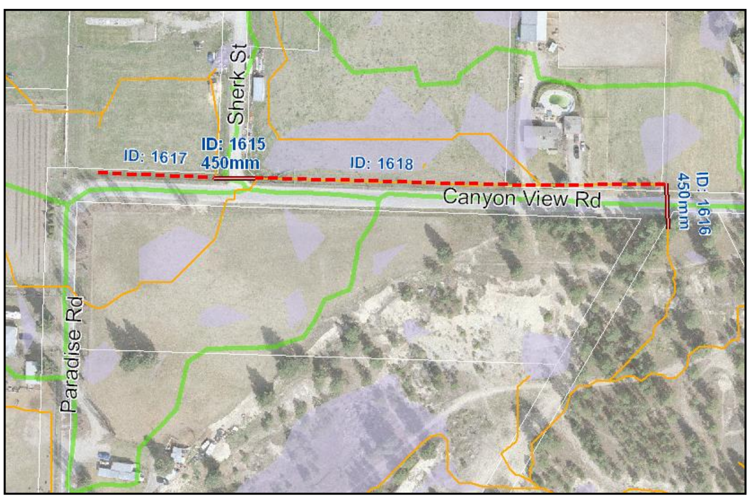
100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1615	0.004	-	-	m^3/s
1616	0.005	-	-	m^3/s
1617	0.004	-	-	m^3/s
1618	0.008	-	-	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$65,700	$65,700	$65,700

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.



Issue:
Poorly defined major drainage along Canyon View Road and Sherk Street increases the risk of erosion and/or flooding from runoff during heavy storms.

Concept:
Improve major drainage route definition and connectivity.

Proposed Works:

Existing System:
Construct ditching along the north side of Canyon View Road with a culvert across Sherk Street and another crossing Canyon View Road at the low point. It is assumed that runoff discharged to the existing ravine would infiltrate rapidly, reducing potentially erosive flows over the steep banks to Trout Creek.

LID System:
There is no anticipated development upstream of the proposed works.

Conventional System:
There is no anticipated development upstream of the proposed works.

Implementation:
Works should be constructed when one of the following occurs:

- Canyon View Road or Sherk Street is upgraded
- Recurring flooding or erosion issues are reported
- Funds are available from the annual capital works budget

Project: WT-02 Mountain Avenue / McGee Street / Paradise Road

Priority: 2

Trigger: Jersey Lands development and/or development west of the golf course.

100 Year Design Flows:

Link ID	Existing	LID	Conventional	
1619	-	0.001	0.001	m^3/s
1620	-	0.004	0.004	m^3/s
1621	-	0.023	0.055	m^3/s
1622	-	0.018	0.068	m^3/s
1623	-	0.028	0.070	m^3/s
1624	-	0.018	0.018	m^3/s
1625	-	0.027	0.070	m^3/s

Estimated Capital Costs:

Existing	LID	Conventional
$0	$92,200	$92,200

Note: Capital costs do not include allowances for land, easement, or ROW purchases, but do include 15% for engineering and 25% for construction contingencies.

Issue:
With the significant amount of development projected on the Jersey Lands site, and to a lesser extent, to the west of the golf course, the current surface drainage routes and non-existing drainage infrastructure will contribute to potential flooding.

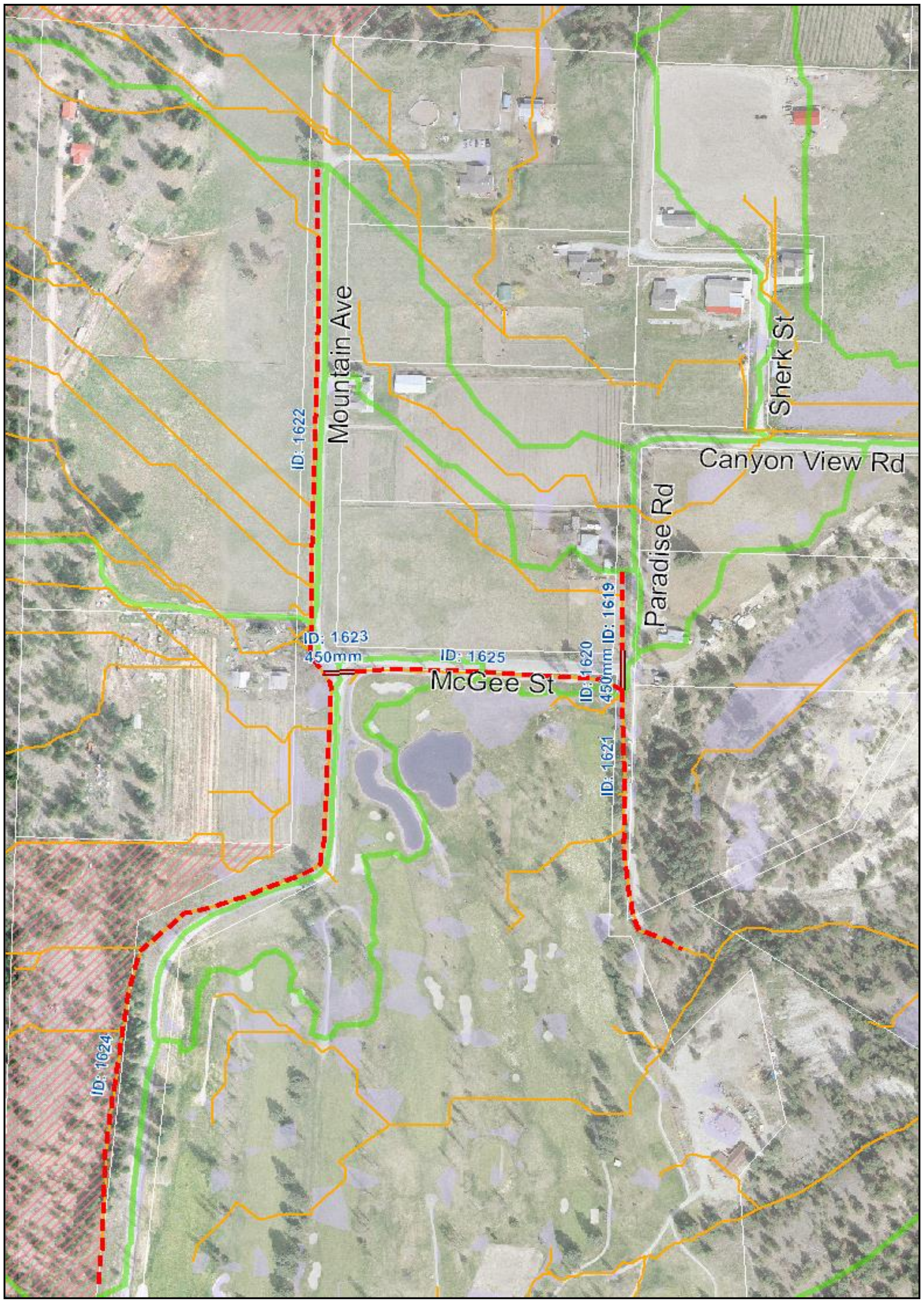
Concept:
Develop a major drainage route to transport flows from upstream developments to Trout Creek.

Proposed Works:

Existing System:
The lack of drainage infrastructure is not considered an existing deficiency since most if not all rainfall infiltrates into the natural and agricultural land.

LID System:
It is assumed that the access to the Jersey Lands site will be an extension of Mountain Avenue. Therefore, the proposed works are based on the assumption that major flows would be directed along this upgraded road. It is further assumed that the road section would be rural, so the proposed works

include ditching and culverts as shown in the following figure. Once the flows are discharged to the ravine east of Paradise Road, it is also assumed that sufficient infiltration will occur to limit the flows which might pass over the steep bluffs to Trout Creek.



Conventional System:
While the works proposed for the LID scenario would have the hydraulic capacity to accommodate projected flows from the development using conventional systems, there is significant concern about potential erosion if such flows were allowed over the bluff above Trout Creek. It is recommended that sufficient runoff attenuation be implemented on-site to limit discharge rates to those generated under LID conditions. Consequently, the proposed works for the Conventional System scenario are the same as those for the LID scenario.

Implementation:
These proposed works should be part of the off-site development requirements. However, because of the potential for erosion should recurring or significantly high flows pass over the bluffs above Trout Creek, additional geotechnical investigation should be completed to:

- Confirm infiltration rates along the existing ravine
- Evaluate potential risks, with respect to stability, of introducing water to the soils above the bluffs
- Recommend mitigative works to address issues identified by the geotechnical study

Also note that easements will be required for the flow routes over the property bounded by Paradise Road and Canyon View Road. Approval from the Ministry of Environment might also be required to discharge to Trout Creek.

6.0 CAPITAL COSTS

This section summarizes the estimated capital costs for all of the projects identified in the *Master Drainage Plan*. It includes a table which summarizes each proposed capital project, its estimated capital cost, assigned priority, and allocation to existing deficiency and/or future development. This latter set of information can be used by the District to develop a capital cost recovery strategy.

6.1 Summary

The estimated capital costs for the proposed projects are given in **Table 6.1** at the end of this section. Note that there is one column for Existing Deficiencies, and two columns each for the LID and Conventional Systems scenarios. Please refer to the following in order to better understand what is being indicated:

- If a proposed project services only existing development, then 100% of its capital cost will appear in the *Existing Deficiencies* column. In this case, the same cost will also appear in the *Estimated Capital Cost* column for both of the future development scenarios.
- If a proposed project services both existing and future development, only the portion of the capital cost allocated for addressing the existing deficiency, appears in the *Existing Deficiencies* column. The *Estimated Capital Cost* column for both of the future development scenarios contains the total capital cost for the project sized to service the future development. The *Allocated To Development* columns display the difference between the total estimated cost and the portion allocated to existing deficiencies.
- In some cases, the *Estimated Capital Cost* for the two future scenarios are different – this is due to different sizing necessary to accommodate different design flows.

Sub-totals are also given based on the assigned priorities. These have been colour-coded for easy reference. Note that the allowances are:

- 15% for Engineering, and
- 25% for Construction Contingencies

6.2 Cost Recovery

The estimated capital costs for the identified projects have been allocated to "Existing Deficiencies" and to "Development". Works identified as an existing deficiency would typically be funded from General Revenues or, if applicable, the Drainage Utility.

The cost of works allocated to development can be recovered through one or more of the following methods:

- developer contribution
- development cost charges
- local improvements

Developer contributions are most suitable for off-site works that primarily service only the proposed development. It is easy to implement, provides the works when required, and usually costs the municipality little or nothing in terms of capital expenditures. (Most such works do, however, become the property of the municipality, and require periodic maintenance.) For significant up-front works which benefit several potential developments, the District can prepare a "late comer" agreement. This allows the initial Developer, who would have to fund 100% of these works, to recover some of his costs from other developers whom might benefit from the works.

Development Cost Charges (DCCs) are usually employed when the works will benefit a large number of developments, usually owned by several different developers. The benefit of this method is that developers contribute only as they develop each phase. The down-side is that if significant works are required at the beginning of development, enough funds usually haven't been collected yet to pay for them. Municipalities must administer the DCC program, and are required by provincial statute to contribute an "assist" amount of capital to ensure the DCC is "fair and equitable".

Local improvements are usually jointly funded by the municipality and the residents of benefiting area. This approach relieves the developer of the capital costs and places them onto the new home owners. It also provides a way of including existing residents if they benefit from the new works.

7.0 GENERAL CONCLUSIONS AND RECOMMENDATIONS

Specific and detailed conclusions and recommendations have been given for each of the proposed projects outlined in **Section 5.0**. The following conclusions and recommendations are therefore more general in nature and provide direction with respect to district-wide stormwater management.

This document should be viewed as an "active" Master Drainage Plan in the sense that it can and should be updated continually as assumptions change and new information is realized. It has been structured to facilitate easy addition or revision of each proposed project so that it can be kept current and continuously applicable to Staff requirements.

7.1 Conclusions

7.1.1 General Hydrology

Based on the events of the July, 2007 storm, agricultural and natural, undeveloped lands have sufficient storage capacity to absorb most of the rainfall delivered by storms with return periods of up to 100 years.

7.1.2 Existing Drainage Systems

Based on anecdotal information and on discussions with District Staff, and supported by hydraulic analysis, the existing storm sewer systems within the study area have sufficient capacity to accommodate peak runoff from the 10-year design storm under existing development conditions. The natural stream channels are intended to carry peak runoff from the 100 year design storm, and except for some capacity deficiencies in Prairie Creek as noted in **Section 5.1**, are able to accommodate anticipated peak flows provided LID techniques are implemented in development and re-development areas.

7.1.3 Development Impacts

It is best to mitigate the impacts of increased impervious area in potential developments on-site rather than through a regional detention facilities or large drainage systems.

With respect to Prairie Creek, there are several development sites within the western part of the Prairie Creek basin, and the logical location for a regional detention facility is upstream of the Giant's Head Elementary school. This would mean that the Prairie Creek stream channel west (upstream) of this site would be subjected to significantly higher flow rates, and would correspondingly require significant upgrades to accommodate them. The existing channel has sufficient capacity to accommodate some additional flows, which is all that is anticipated if Low Impact Development techniques are implemented in each development.

7.1.4 Conventional vs. Low Impact Development

Two servicing concepts were considered; a conventional storm sewer system and a Low Impact Development (LID) system which incorporates perforated pipe and drywell infiltration, on-site detention storage, and disconnected impervious areas. Overall, the LID system was less expensive than the conventional system because it reduced the size of several long storm sewers. More significantly, by assuming use of LID techniques in the large development sites located far from Okanagan Lake, the moderate increase in peak flows from the design 100 year rainfall event could be accommodated with few downstream improvements. Use of conventional drainage systems to service large developments located a significant distance from Okanagan Lake or Trout Creek (receiving waters), is considered economically infeasible.

Analysis also indicated that the use of conventional drainage systems within the downtown area could create peak flows within Prairie Creek that exceed the capacity of portions of its pipe reaches downstream of Rosedale Avenue.

7.1.5 Silt Bluff West of Butler Street

While the Prairie Creek stream channel has sufficient capacity between Highway 97 and the west end of Butler Street, it appears to be susceptible to impacts from the silt bluff on its north bank. While the risk of blockage due to sloughing may be low, the downstream impacts should this happen are high.

7.1.6 Stormwater Quality

Many of the existing piped drainage systems which discharge directly to Okanagan Lake, are not equipped with units to improve stormwater quality. Generally, however, infiltration and flows through grassed swales and ditches reduces the amount of pollutants entering the streams and ultimately, Okanagan Lake.

7.1.7 Allowable Discharge Rates For New Developments

The District requires new developments to attenuate post-development flows to pre-development levels. However, the current methods used to establish pre-development peak flows were developed for design purposes, and therefore yield conservatively higher values than what would be normally observed. This means that existing drainage systems downstream of new development are often subjected to increased flow rates even though the intent was to control post-development flows to pre-development levels. In some cases, this has created - or will create, downstream capacity deficiencies and unanticipated upgrading requirements.

7.1.8 Uncontrolled Soil Removal

Stripping land of its natural or planted organic layer without adequate measures to ensure that potential runoff is managed, can and does result in downstream impacts.

7.2 Recommendations

7.2.1 Implement Low Impact Development Techniques

Since the LID techniques reduce peak flows, provide some capital cost savings, and promote better stream health, the District should take the steps necessary to ensure that they are implemented in future developments and re-developments.

7.2.2 Allowable Unit Discharge Rates

For developments required to attenuate post-development runoff to pre-development levels, implement a simplified method of establishing the allowable (pre-development) flow rate using the following unit runoff rates:

- 0.5 Lps/ha for 10 year events or less (minor system)
- 1.0 Lps/ha for up to 100 year events (major systems)

7.2.3 Earthworks Controls

Ensure that under the proposed District Earthworks bylaw, adequate provisions are made to manage any potential runoff from areas which are to be stripped of the organic topsoil layer.

7.2.4 Use Projects for Capital Planning

This document is intended to facilitate annual capital works planning and budgeting. Since triggers and priorities have been identified for each project, District Staff should review the projects annually and select the ones that should be included in the next Capital Works Plan. In some cases, the identified projects could be divided into phases that can be implemented over several years.

7.2.5 Address Stormwater Quality

In order to address existing deficiencies with respect to the quality of stormwater discharged to Okanagan Lake, the District should budget at least $100,000 per year to install stormwater quality enhancement units on existing piped drainage systems which discharge to the lake.

7.2.6 Use Master Drainage Plan Document as Reference

Because the proposed projects have been organized geographically, it is relatively easy to identify any drainage projects that should be implemented because of other activities within the study area. Therefore, when road or utility upgrades are being considered, or when development proposals are submitted, Staff should refer to this document in order to determine if any of the projects are required or should be implemented.

7.2.7 Update Frequently

This document will become out-dated quickly unless Staff keeps it updated. Because of the way it is organized, Staff should remove the project sheets for projects which have been completed, and replace them with a reference to as-constructed drawings. Staff should also make notations to project sheets when the circumstances surrounding a project change.

7.2.8 Electronic Data

While the paper copy of this document is valuable as a reference and guide, there is a significant amount of corresponding data available electronically for the drainage catchments and systems within the study area. These data include design flow rates, physical characteristics, and performance metrics for both the existing and proposed drainage infrastructure. These should be referenced when more detail than that contained in this document is required.

APPENDIX A

SUPPORTING FIGURES AND TABLES

Figure A-1
IDF Curves

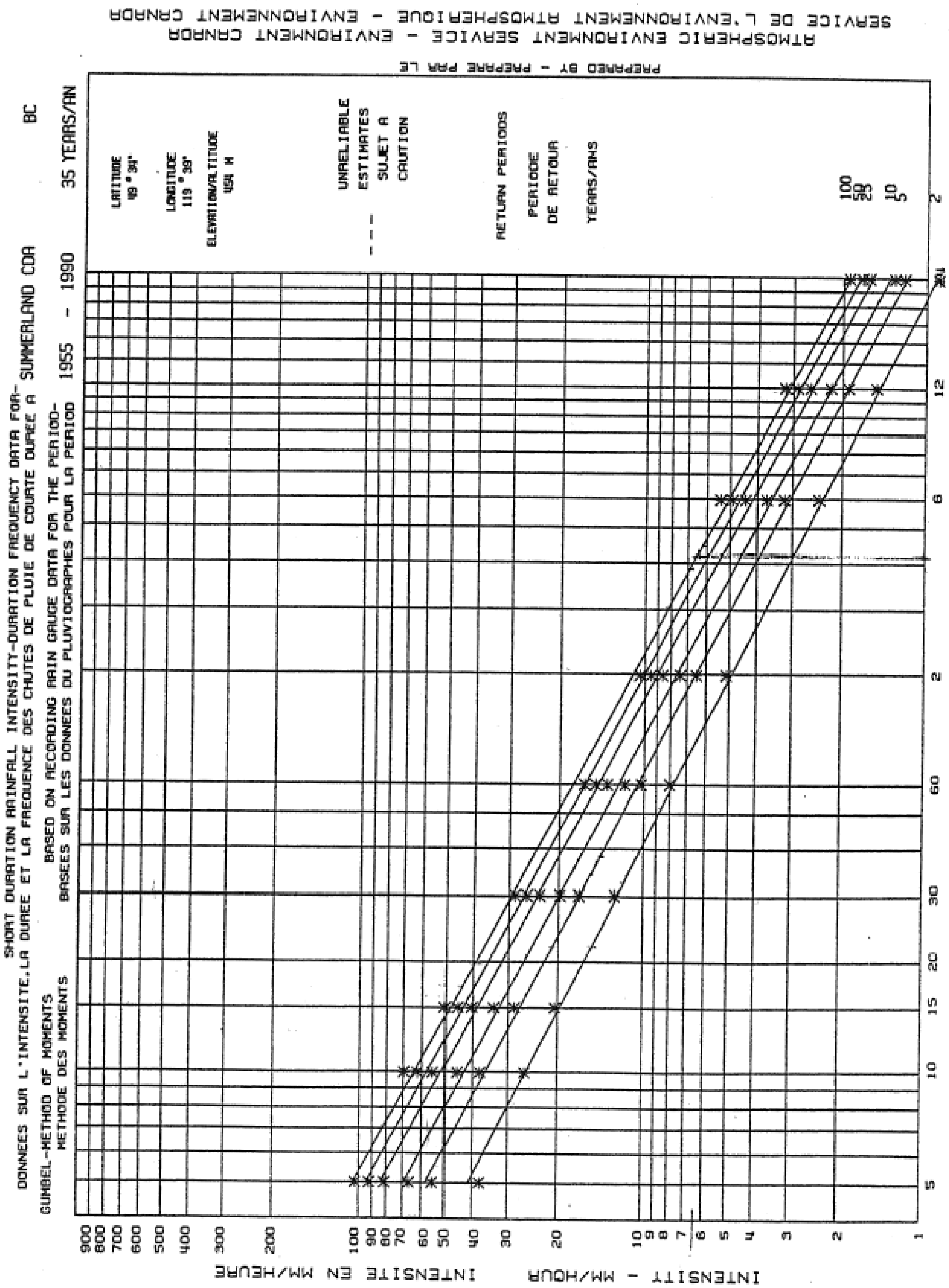
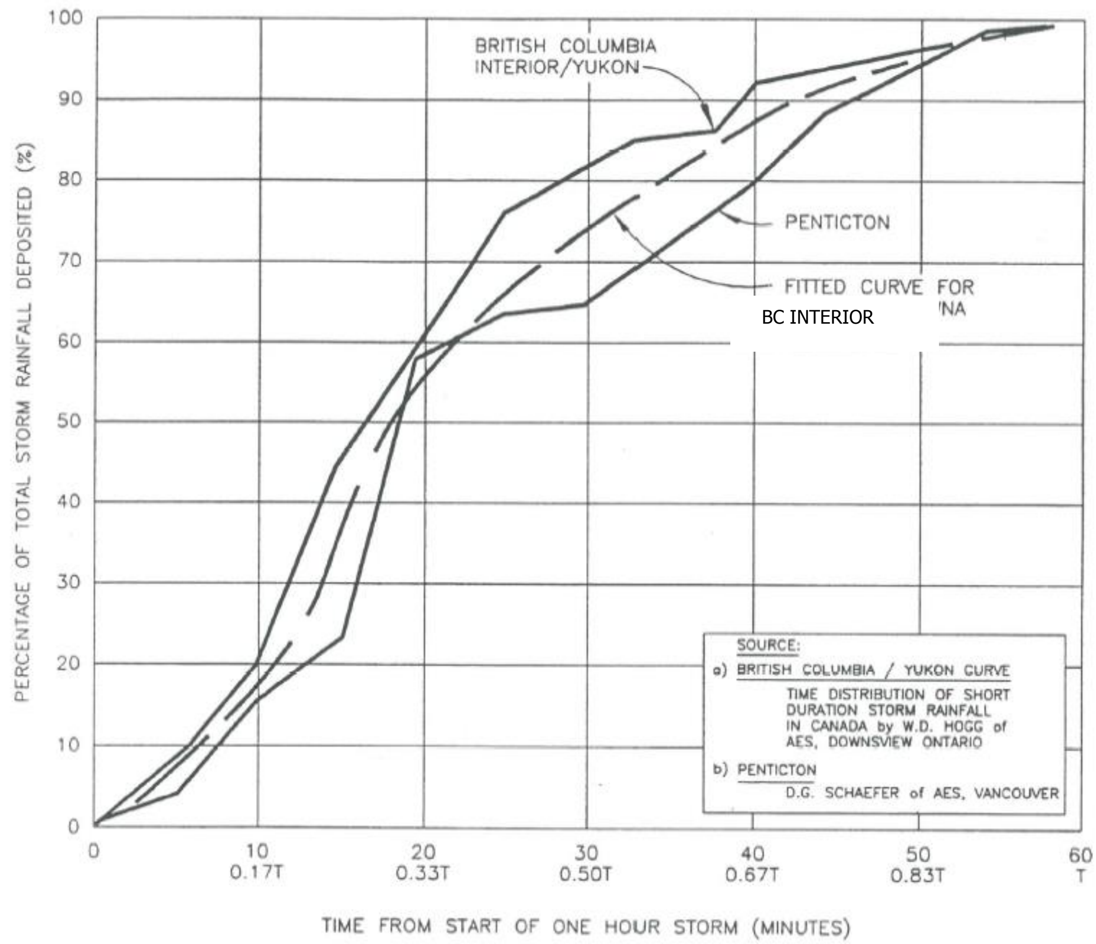


Figure A-2

CURVES SHOW THAT 50 % OF SELECTED ONE HOUR STORM RAINFALL EVENTS DEPOSIT A CERTAIN PERCENTAGE OF TOTAL STORM RAINFALL IN A SPECIFIED TIME PERIOD



1 HOUR STORM FOR ≲ 6 HOUR (SHORT STORMS) RAIN DISTRIBUTION PATTERN

Figure A-3

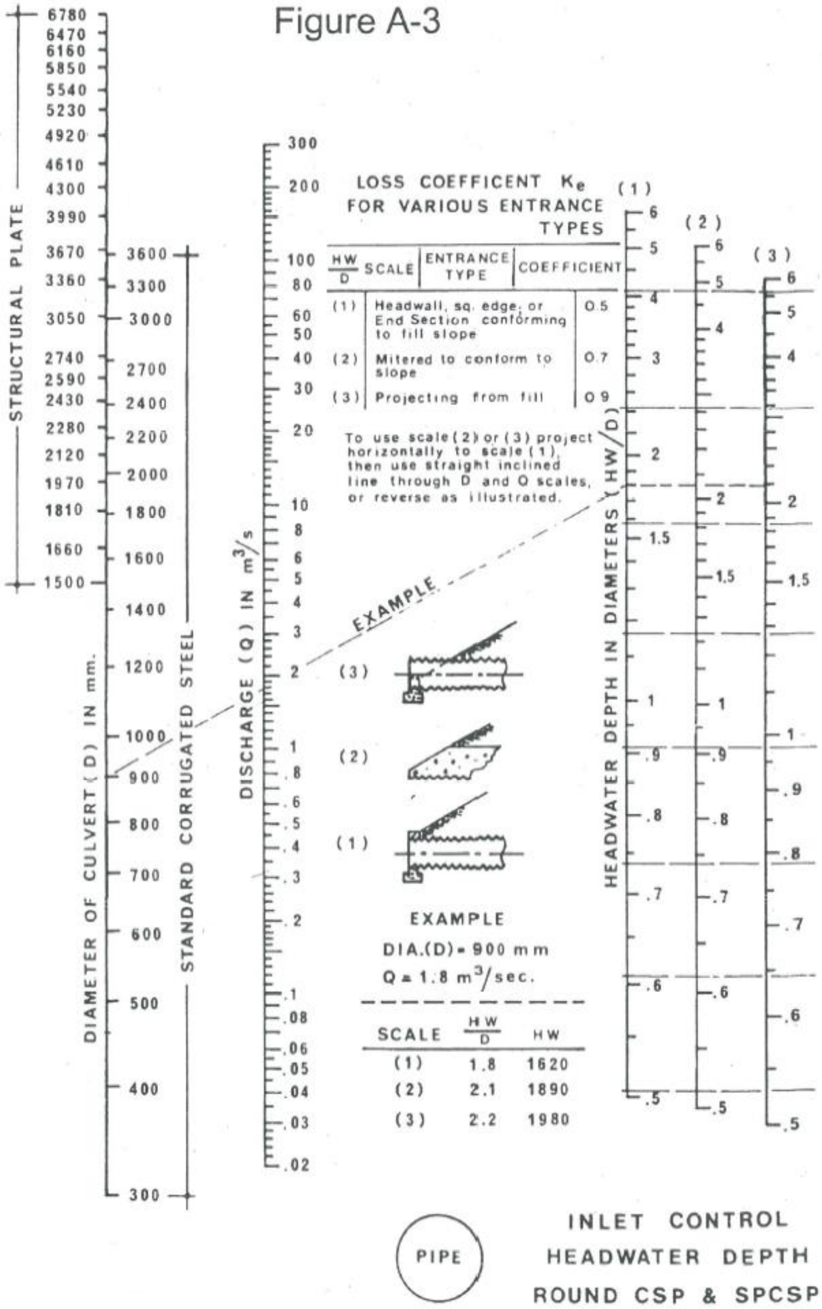


Figure 4-29 *Inlet control* nomograph for corrugated steel pipe culverts. The manufacturers recommend keeping HW/D to a maximum of 1.5 and preferably to no more than 1.0. Data is derived from nomographs published by the Bureau of Public Roads.[9]

Table A-1

Total Rainfall Calculations

AES Station: **Summerland**

PPT = A*T^(1+B) where: PPT = Total rainfall (mm)
A = AES coefficient
T = Storm duration (hours)
B = AES coefficient

Return Period (Yrs)	10	25	100
coefficient A	12.12	14.68	17.72
coefficient B	-0.7059	-0.7140	-0.7221

T (hrs)	T (min)	PPT -Total Rainfall (mm)		
0.5	30	9.9	12.0	14.6
1	60	12.1	14.7	17.7
2	120	14.9	17.9	21.5
6	360	20.5	24.5	29.1
12	720	25.2	29.9	35.3
24	1,440	30.9	36.4	42.8
48	2,880	37.9	44.4	51.9

Table A-2 (PAGE 1)

TYPICAL MANNING ROUGHNESS COEFFICIENTS	
CLOSED CONDUITS	**Manning "n" Range**
Concrete pipe and box	0.012
Corrugated steel pipe or pipe arch • Unpaved • 100% Paved	 0.024 0.012
PVC (smooth)	0.011
LINED OPEN CHANNELS	**Manning "n" Range**
Concrete • Formed, no finish	 0.013 – 0.017
Gravel bottom sides • Formed concrete • Dry rubble (rip-rap)	 0.017 – 0.020 0.023 – 0.033
Asphalt • Rough	 0.016
UNLINED OPEN CHANNELS	**Manning "n" Range**
In clean gravelly/soil, uniform section	0.022 – 0.025
Earth • Grass, some weeds • Sides clean, gravel bottom	 0.030 – 0.035 0.025 - 0.030
Channels not maintained, vegetation uncut: • Dense weeds, high as flow depth	 0.080 – 0.12
NATURAL STREAM CHANNELS	**Manning "n" Range**
Minor streams • Dense growth of weeds	 0.035 – 0.050
HIGHWAY CHANNELS AND SWALES WITH MAINTAINED VEGETATION	**Manning "n" Range**
Depth of flow from 0.20m: • Bermuda grass, Kentucky Bluegrass: – Length 0.10 to 0.15m – Length about 0.30m – Length about 0.60m	 0.050 – 0.090 0.090 – 0.180 0.150 – 0.300

Table A-2 (PAGE 2)

Depth of flow from 0.20m to 0.45m: • Bermuda grass, Kentucky Bluegrass: – Length 0.10 to 0.15m – Length about 0.30m – Length about 0.60m	 0.040 – 0.060 0.070 – 0.120 0.100 – 0.200
STREET AND EXPRESSWAY GUTTERS	**Manning "n" Range**
Concrete gutter, trowelled finish	0.012
Asphalt pavement • Rough texture	 0.016
TYPICAL MANNING ROUGHNESS COEFFICIENTS	
OVERLAND FLOW	**Manning "n" Range**
Dense turf	0.300 - 0.480
Dense shrubbery and forest litter	0.400
Concrete or asphalt	0.010 - 0.013
Gravelled surface	0.030 - 0.012
Bare clay-loam (eroded)	0.120 - 0.033
Range (natural)	0.010 - 0.320

Table A-3

MAXIMUM RECOMMENDED VELOCITIES IN EARTH AND GRASS LINED CHANNELS			
EARTH – SOIL TYPE	**PERMISSIBLE VELOCITIES M/Sec**		
Fine Sand (noncolloidal)		0.5	
Sandy Loam (noncolloidal)		0.5	
Silt Loam (noncolloidal)		0.6	
Ordinary Firm Loam		0.9	
Fine Gravel		1.2	
Stiff Clay (very colloidal)		1.4	
Graded Loam to Cobbles (noncolloidal)		1.4	
Graded, Silt to Cobbles (colloidal)		1.7	
Alluvial Silts (noncolloidal)		0.9	
Alluvial Silts (colloidal)		1.4	
Coarse Gravel (noncolloidal)		1.8	
Cobbles and Shingles		1.7	
Shales and Hard Pans		1.8	
GRASS LINED	**<0.5%**	**5 – 10%**	**>10%**
Erosion Resistant Soils	1.2	0.9	0.7
Highly Erodible Soils	0.9	0.7	0.5

Note: A variety of values for each soil type are recommended by various authors. The above values are more conservative for soil types considered highly erosive.

Table A-4

Rational Method Typical R Coefficients for 5- to 10-Year Frequency Design (From ASCE, 1972 (Ref. 11)

Description of Area		Runoff Coefficients, R
Business		
	Downtown Area	0.82
	Neighbourhood areas	0.60
Residential		
	Single-family areas	0.40
	Multiunits, detached	0.55
	Multiunits, attached	0.65
Residential (suburban)		0.30
Apartment dwelling areas		0.60
Industrial		
	Light areas	0.65
	Heavy areas	0.75
Parks, cemeteries		0.15
Playgrounds		0.25
Unimproved areas		0.15
Streets		
	Asphaltic	0.80
	Concrete	0.85
	Brick	0.75
Drives and walks		0.80
Roofs		0.75
Lawns: Sandy Soil		
	Flat 2%	0.05
	Average 2-7%	0.10
	Steep 7%	0.15
Lawns: Heavy Soil		
	Flat 2%	0.15
	Average 2-7%	0.20
	Steep 7%	0.25

* The coefficients may be approximated by calculating the fraction of directly connected impervious area such that;

$R = 0.9\ (Imp) + a\ (1\text{-}Imp)$ where, Imp is the impervious directly connected fraction and 'a' is a variable depending on soil or antecedent moisture generally for AMC = 1, a = 0.1, AMC = 2., a = 0.2 and AMC = 3, a = 0.3.

Table A-5

Assumed Unit Capital Costs ($/ lineal metre): 2006 Dollars

Pipes and Associated Works — *Diameter (mm)*

Item	250	300	375	450	525	600	675	750	900	1050	1200	1350	1500
Storm mains (<= 675mm is PVC; => 750mm is Concrete)	115	132	155	190	224	270	334	760	923	1,086	1,249	1,412	1,575
Perforated Storm Sewer	127	146	160	170	248	299	369	n/a	n/a	n/a	n/a	n/a	n/a
Manholes (1 per 100m)	31	31	31	31	45	45	50	50	66	76	84	98	98
Drywells (1 per 100m)	30	30	30	30	30	30	30	n/a	n/a	n/a	n/a	n/a	n/a
Catch Basins (2 per 100m)	26	26	26	26	26	26	26	26	26	26	26	26	26
Catch Basin Leads (30m per 100m)	24	24	24	24	24	24	24	24	24	24	24	24	24
Concrete Curb & Gutter c/w driveway ramps (2 sides)	50	50	50	50	50	50	50	50	50	50	50	50	50
Dewatering	30	30	30	30	42	42	42	42	42	54	54	54	54
Minor Road Restoration -Gravels and Asphalt (2 lanes)	191	191	191	191	191	191	191	191	191	191	191	191	191
Major Road Restoration -Gravels and Asphalt (2 lanes)	368	368	368	368	368	368	368	368	368	368	368	368	368

Culverts, Trenches, and Associated Works — *Diameter / Channel Bottom Width (mm)*

Item	250	300	375	450	500	600	675	750	900	1050	1200	1400	1600
CSP Culverts (including headwalls and road restoration) - L.S.	21,300	21,900	22,600	9,200	10,600	12,900	14,100	16,900	19,500	21,400	23,200	25,200	26,900
CSP Pipe	60	75	95	135	168	210	244	274	310	370	409	453	500
Ditching (excavation and disposal; 2:1 sides; 0.5 m deep)	n/a	n/a	n/a	5.80	6.00	6.40	6.70	7.00	7.60	8.20	8.80	9.60	10.40
Erosion protection - root reinforcement	n/a	n/a	n/a	47	47	48	49	50	51	53	54	56	58
Erosion protection - Rip Rap (Class 25)	n/a	n/a	n/a	183	185	189	192	194	200	206	212	220	228
Erosion protection - Rip Rap (Class 50)	n/a	n/a	n/a	230	232	237	241	244	252	259	266	276	286

Add 15% for Engineering and 25% for Construction Contingency

Notes:

Storm main prices based on a 2.5m invert depth and include the following:
- *trench excavation*
- *supply and installation of pipe*
- *supply, placement and compaction of bedding material*
- *placement and compaction of native backfill to subgrade*
- *cleaning and videoing*
- *traffic control*

Minor road restoration (one lane) is based on the following:
common excavation to sub-grade; offsite disposal
sub-grade finishing and compaction
300mm granular sub-base (pitrun)
100mm granular base (crush)
60mm asphalt

Major road restoration (one lane) is based on the following:
common excavation to sub-grade; offsite disposal
sub-grade finishing and compaction
450mm granular sub-base (pitrun)
150mm granular base (crush)
100mm asphalt

APPENDIX B

BEST MANAGEMENT PRACTICES

BEST MANAGEMENT PRACTICES

This section introduces Best Management Practices (BMPs) that are most applicable to supporting low impact development (LID) initiatives (reducing runoff volume and peak flows from new developments). Selection is based on stormwater conditions in the Okanagan, and modified where appropriate. The source documents include:

- the *Best Management Practices Guide for Stormwater, October 1999,* by the Greater Vancouver Sewerage and Drainage District
- *Water Balance Model* website – www.waterbalance.ca
- Vendor websites

In addition to volume and peak flow control, some of the BMPs also provide stormwater quality improvement by removing or reducing the amount of suspended matter and hydro-carbons.

Buffer Zones/Preservation of Natural Areas & Drainage Systems

Description:

Natural features such as lakes, wetlands, streams, soils, depressions, and riparian zones all play an important role in the hydrology of an area. They each play a role in storing, attenuating, infiltrating, evaporating, and purifying runoff. Removing or modifying one or more of these features as part of the development process has a significant and permanent effect on the remaining downstream features, and ultimately on overall stormwater quality. With thoughtful planning, these features can be preserved and integrated into the development process, thereby minimizing associated negative impacts.

Implementation:

In order to preserve the indicated resources, it is essential to identify and map each one prior to the development process. These maps should be included planning documents and each associated property should be flagged to alert Staff when development applications are received.

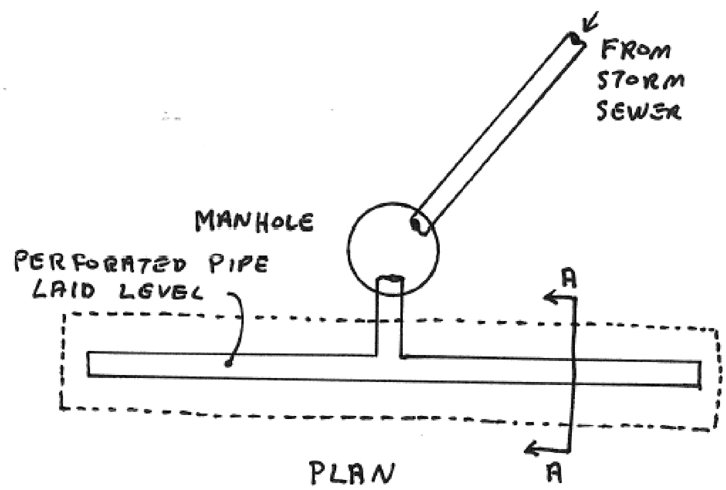
Issues:

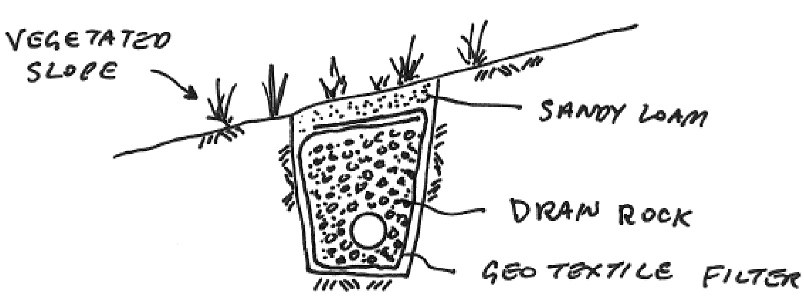
While preserving natural drainage features (especially riparian buffer strips) helps to improve stormwater runoff quality, it is a BMP that cannot function on its own. Structural and maintenance BMPs must also be implemented as part of the development process to initiate the flow reduction and general stormwater quality improvement process. This is essential so that:

- The natural features are not short-circuited by direct discharges to receiving waters,
- The preserved natural features are not altered by excessive flow rate increases or excess contaminants.

Application:

Instead of discharging directly to a receiving water or natural drainage channel, an exfiltration outlet could be employed for the more frequent runoff events. As shown below, water would either infiltrate into or the ground, or move through the shallow soil layer into the stream or natural channel. Under higher runoff conditions, the stormwater would rise and flow over the surface, but in a dispersed manner. Only under extreme conditions would the manhole overflow.





Impervious Area Reduction/Restriction/Disconnection

Description:

Impervious area reduction/restriction/disconnection can be undertaken by reducing the overall size of the developed area. It can also be accomplished by reducing the amount of impervious surface created within the development itself. Runoff from a variety of sources can be more appropriately directed to vegetated surfaces, rather than over impervious surfaces. This allows for the critical infiltration to occur, which is lacking with the extensive presence of impervious surfaces.

This BMP works well in conjunction with the establishment of buffer zones and preservation of riparian areas, natural vegetation, and drainage systems.

Implementation:

For the successful implementation of impervious area reduction, it necessary to:

- Integrate impervious area reduction into the policies and regulations documents, in particular the Subdivision and Development Servicing Bylaw and the Official Community Plan.
- Encourage developers to employ innovation in their layouts and use of landscaping/buffers
- Evaluate current engineering standards and revise as necessary to ensure that required impervious areas are minimal, and that land clearing activities and compaction for and during development are limited, especially on those sites with sensitive features.

The implementation of this BMP will require openness on the part of existing staff to innovative ideas since some concepts will necessitate a different approach to operations and maintenance. Examples include, but are not limited to:

- Maintenance of landscaped buffers – mowing, pruning, litter removal, and occasional removal of collected sediments.
- Increased inspection.
- Care during snow removal to avoid gouging the landscaping.
- Education of home owners for on-site BMPs.
- Education of the public in general since anything "different" is usually greeted with suspicion.
- Instituting community participation to care for "adopted" streets or stream channels.

Since this BMP impacts policies, long-range plans, servicing standards, and the development community, it is one of the more difficult to implement. However, it is essential that discussions regarding this BMP be initiated as soon as possible among both the District Staff and the development community. These discussions should focus on what measures can be taken, what the impacts would be to each of the stakeholders, and how to best mitigate these impacts. By initiating these discussions early, and obtaining consensus among the stakeholders, appropriate measures can be incorporated into the various policies and plans when they are reviewed.

Application:

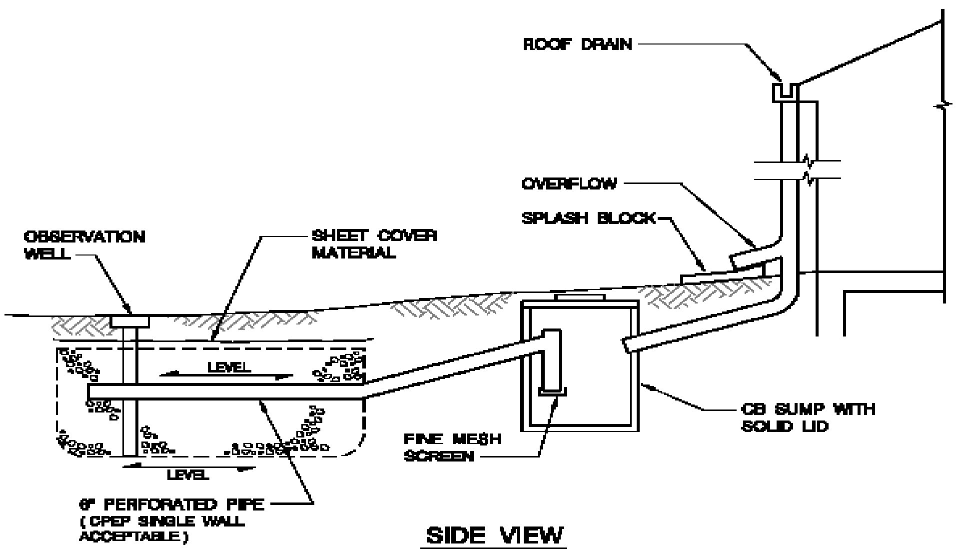
The following are examples of how both the total and directly-connected amounts of impervious area can be reduced. Notice that the primary method of disconnection eliminates the traditional curb & gutter system.

Narrower Road Surface / Flush Curbs

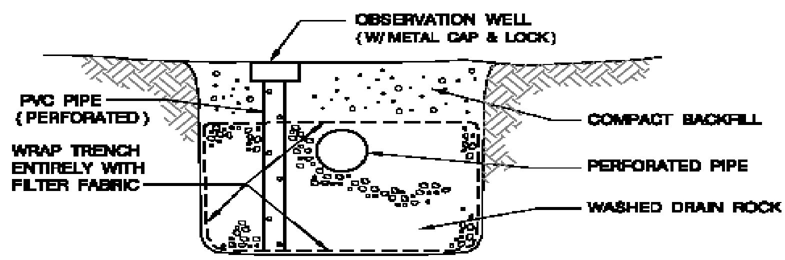
Road width standards can be reviewed and adapted to improve stormwater management. Combined with one or more of the other BMPs outlined in this appendix, narrower roads (less total impervious area) combined with flush curbs to allow runoff to flow onto pervious area (less directly connected impervious area) can be very effective.

Roof Downspout System

Roof downspout systems are a type of infiltration system intended only for infiltrating the runoff from roof downspout drains; they are not designed to handle general site runoff (e.g., from paved areas, lawns, etc.). The means of infiltration in roof downspout systems may be via sub-surface infiltration trenches filled with drain rock, sub-surface sand filters, dry wells (sub-surface reservoirs made from large diameter pipes set on end over a base of washed rock), sub-surface perforated infiltration tanks, dispersion (open-top) trenches (including rock pockets and French drains), or surface dispersion.



SIDE VIEW
NTS



SECTIONAL VIEW
NTS

Rooftop runoff is commonly described as "relatively clean" in design manuals, and is consequently considered safe for infiltration without prior treatment. Subsurface systems (infiltration trenches, tanks, and dry wells) provide temporary storage of runoff and provide an opportunity for it to infiltrate into the surrounding soil. Surface dispersion systems rely on vegetated surfaces to infiltrate stormwater. Roof downspout systems can accomplish runoff peak flow, volume reduction, and groundwater recharge. Some removal of contaminants is possible as the water infiltrates into the surrounding soil.

Bio-retention/Infiltration (Water Garden)

Bio-retention is a type of stormwater filtering system where runoff is temporarily stored in a shallow depression and then allowed to gradually infiltrate through a constructed filter bed of soil and plants to an underlying drain system. The bio-retention system consists of a flow regulation structure/level spreader with a vegetated filter strip or grass channel leading to a shallow ponding area. The ponding area contains a surface layer of organic mulch, underlain by a planting soil bed that supports turf, shrubs, and trees, underlain in turn by a sand bed and then an under drain system.

Bio-retention systems are normally designed to handle lower flows only; larger flows are bypassed via an overflow gravel curtain and a high flow overflow structure. Contaminant removal mechanisms include filtration, adsorption, volatilization, ion exchange, microbial action, and plant uptake.

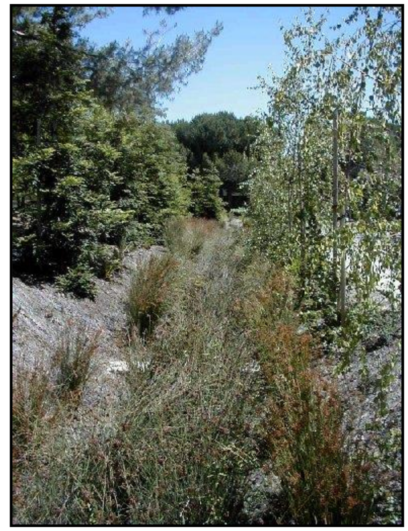
Issues:

In order for impervious area reduction/restriction/disconnection to be effective, it will likely require the enforcement of policies and standards as set out in official community plans, zoning bylaws, growth management strategies, and subdivision and development servicing bylaws. This could possibly be the most challenging issue to be faced.

Vegetated Swale/Grassed Channel

Description:

Swales are natural depressions or wide, shallow channels. Grassed channels are gently sloped, open ditches lined with turf grass or native vegetation. The vegetation helps to decrease stormwater flow velocities, which helps to reduce peak flow rates. This in turn helps to reduce flooding and stream bank erosion. Some of the flow may also infiltrate into the ground, reducing the overall runoff volume. Removal of contaminants, including oil, grease, and suspended solids, can be accomplished through filtration by plant stems, adsorption to soil particles, and biological processes. An example of a vegetated swale is shown below.



Vegetated swales are technically simple, are particularly suited alongside roadways and parking lots, and can be used as a pre-treatment for other BMPs. With proper design and maintenance, they are also capable of lasting 10-20 years.

Given the many rural roads within the subject area, this area-specific BMP with its simplicity, low cost, and effectiveness, was recognized as being very applicable to the area and an appropriate tool in managing stormwater quality.

Implementation:

The implementation of vegetated swales within the study area is relatively straight-forward. In many of the District's rural and residential areas, vegetated swales (grassed shoulders) are already used. For the successful implementation of this area-specific BMP, it is recommended that the District:

- continue the practice of implementing vegetated swales along all rural roads within the study area;
- amend its policies, bylaws and standards to allow for the incorporation of vegetated swales in new developments.

Issues:
While vegetated swales are very simple, inexpensive and effective for the removal of many contaminants and for reducing flows by encouraging infiltration, they have some issues associated with them which require consideration prior to the implementation of this area-specific BMP. Vegetated swales:

- are less effective for the removal of soluble metals and nutrients;
- are only affect a maximum contributing area of 2 ha;
- are only effective on sites with slopes up to a maximum of 6%;
- are susceptible to erosion;
- are susceptible to sediment accumulation;
- may have vegetation critical for the removal of contaminants destroyed during maintenance for the removal of collected sediments;
- may require irrigation during dry season.

Vegetated Filter Strip

Description:
Vegetated filter strips are similar in some respects to vegetated swales in that runoff is directed to flow over a vegetated surface. However, filter strips are broad areas that promote even sheet flow over a sloped vegetated ground surface, as shown in the adjacent figure. The vegetated surface can range from turf to forest.

The design of vegetated filter strips allows for stormwater flows to be intercepted and directed over the vegetated surface before the flows become substantially concentrated. Some infiltration may occur, and the time of concentration is increased; this may result in some attenuation of peak runoff rates for flood control and stream bank erosion protection, although other additional BMPs are typically required for these purposes.

Vegetated filter strips are particularly suited alongside roadways, parking lots, and paved sites without underground collection and conveyance systems. They provide effective removal of particulates and low concentrations of oil and grease, enhancing water quality from general urban runoff. While all vegetated filter strips help to reduce watershed imperviousness, forested vegetated filter strips also help to preserve the character of riparian/buffer zones and provide for wildlife habitat.

Although this BMP has a lower overall effectiveness, it is very good at removing target pollutants from, as well as reducing or eliminating, low flow runoff from small areas.. It is also effective as a pre-treatment for bio-retention areas. With proper design and maintenance, this area-specific BMP can last for 10-20 years.

Implementation:

The implementation of vegetated filter strips within the study area would best be achieved by introducing strategically-place green space along the higher-impervious areas. The key is to ensure runoff entering the top of the strip is distributed evenly to induce sheet flow.

Issues:

Issues associated with vegetated filter strips include:

- high density developments may generate flows that are too high for filter strips to be completely effective;
- the maximum contributing drainage area is 2 ha;
- vegetated filter strips must be protected from activities that may channelize flows;
- effective contaminant removal may not occur on slopes exceeding 10%;
- vegetation density and health must be maintained, requiring attention to growth factors such as shade, adequate watering, soils, and appropriate species;
- requires more land area than other BMPs.

Bio-retention, Dry Swale with Under Drains

Description:

Bio-retention temporarily stores stormwater runoff in a shallow depression. This runoff then gradually filters through a constructed filter bed to an underlying drain system. Bio-retention systems are normally designed to handle the water quality volume only, with larger flows bypassed. Contaminant removal mechanisms include filtration, adsorption, volatilization, ion exchange, microbial action and plant uptake. Bio-retention has a greater diversity in structure than most other BMPs, and it is designed to mimic the natural hydrological cycle. If forested, bio-retention can also provide wildlife habitat.

Dry swales are basically a design variant of bio-retention and are mainly applied to moderate to large lot residential land uses. Dry swales are designed to temporarily store the water quality volume behind a weir, and then allow it to infiltrate through a soil bed to an under drain system. Flows that are greater than the water quality volume pass over the weir and out of the swale. Contaminant removal mechanisms for dry swales are similar to that of bio-retention.

Both bio-retention and dry swales have a high potential for the removal of particulate, colloidal and dissolved contaminants, and a wider potential application than infiltration. Both are an excellent option for smaller developments since they can be incorporated into the landscaping, and where soils are suitable, can enhance ground-water recharge. This area-specific BMP is a relatively inexpensive alternative to more complex BMPs.

Implementation:

This BMP could be implemented as follows:

- Encourage developers to construct bio-retention structures as part of the landscaping for their parking lot projects.
- Incorporate bio-retention into residential lot landscaping. This could be applied to both existing and new developments.
- Locations along existing roads should be identified for potential bio-retention structures. These could be constructed as part of the offsite works associated with development, or as part of an annual upgrading program.

Issues:

- Maximum contributing area is 2 ha
- Bio-retention is mainly suited to smaller areas

- Maximum site slope for bio-retention is 6%
- Both bio-retention and dry swales are relatively new practices
- Relatively high construction costs and more complex to construct than most other BMPs
- Delayed efficiency until plants are well established

Amended Soils

Description:

Soil amendments increase the spacing between soil particles so that the soil can absorb and hold more moisture. This in turn reduces runoff and the damaging effects of excessive runoff on local streams. The soil amendments also change various physical, chemical and biological characteristics so that the soils become more effective in maintaining water quality. The temporarily stored runoff is eventually infiltrated to ground and/or transpired by the landscape vegetation.

Implementation:

While the general intent is for new and re-development to incorporate this BMP into its landscape design, it will be necessary for the District to either prescribe it, or suggest it as an acceptable method to meet performance standards for runoff. In either case, the District must be prepared to educate both staff and the development community in the correct design and application of amended soils.

Issues:

- Adds cost to the development.
- Places more responsibility on individual home owners to properly maintain their systems.
- Requires soils testing and careful design to ensure performance and to avoid groundwater mounding problems (especially near building foundations).

Application:

While the specific design is dependent upon local conditions, amended soils are typically employed where natural infiltration is on the lower end of the continuum. They can be incorporated into the landscape design as lawn or landscaped features. Soil depth typically ranges from 0.3m for lawns to 0.8m for landscaped features.

This BMP works well with other BMPs that involve redirecting runoff from hard surfaces onto pervious surfaces (roof down spouts; flush curbs, etc…).

Infiltration to Ground

Description:

Under natural conditions, only 10 – 15% of the annual rainfall from most events ever becomes surface runoff – primarily due to infiltration to the ground. While some soils have very low permeability, most have some capacity to allow runoff to drain through them.

When runoff is collected and concentrated, it is much more difficult to introduce the runoff into the ground than when it is distributed over the entire catchment surface. Therefore, structural systems have been developed to enhance the infiltration process.

Implementation:

Whenever a development application is submitted, it should include a geotechnical report which:

- assesses infiltration capacity of the site’s soils, and
- provides design criteria for infiltration systems.

Mapping should be prepared and used which indicates the areas most suitable for infiltration system use. The District must also indicate that infiltration is a desired rainfall management method in its OCP. The subdivision bylaw must provide the guidance and set the standards for designing and constructing acceptable systems.

Issues:

- Provisions are still required to accommodate runoff which exceeds system capacity.
- Road and system maintenance (street sweeping; CB cleaning) may have to be increased to increase the life span of the systems.
- On hillsides, slope stability under saturated conditions must be studied and taken into consideration.

Application:

There are a variety of structures that can be used to promote and facilitate infiltration of rainfall runoff to ground. These are outlined below.

- Traditional dry wells
- Perforated pipe with drain rock trenches
- Manufactured systems (Infiltrator, Atlantis)

Porous Pavements / Surfaces

Description:

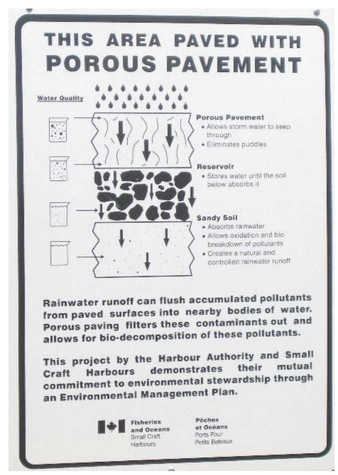
Where hard surfaces are necessary or highly desired, infiltration can still be encouraged by use of more permeable materials or structures. These systems allow rainfall to pass through to the sub soils, where it can continue infiltrating.

Implementation:

Use of more permeable hard surface materials and systems is increasing in Canada. The District must be willing to accept these types of systems in lieu of more traditional hard surfaces. Standards must be developed (subdivision bylaw) to ensure acceptable design and installation. The District may also elect to lead with demonstration projects and developer / contractor information sessions.

Issues:

- Primarily applicable to low / light traffic areas (Pedestrian / cycle paths are excellent applications)
- Underlying soils must have an acceptable infiltration capacity.
- Groundwater table must be considered.
- Typically costs more than conventional hard surfaces.
- May require additional or different maintenance procedures.



Application:

Porous Pavement

Porous pavement is a permeable pavement surface with an underlying stone reservoir that temporarily stores surface runoff before infiltrating into the subsoil. This porous surface replaces traditional pavement, allowing parking lot runoff to infiltrate directly into the soil and receive water quality treatment. There are several pavement options, including porous asphalt, pervious concrete, and grass pavers. Porous asphalt and pervious concrete appear the same as traditional pavement from the surface, but are manufactured without "fine" materials, and incorporate void spaces to allow infiltration. Grass pavers are concrete interlocking blocks or synthetic fibrous grid systems with open areas designed to allow grass to grow within the void areas. Other alternative paving surfaces can help reduce the runoff from paved areas but do not incorporate the stone trench for temporary storage below the pavement. While porous pavement has the potential to be a highly effective treatment practice, maintenance has been a concern in past applications of the practice.

Concrete Grid / Modular Pavers

Concrete grid and modular pavers consist of strong structural materials with regularly interspersed void areas filled with pervious material (normally soil). The structural materials provide a load bearing surface for vehicles, and the interspersed void areas allow infiltration of stormwater to the underlying soil. The structural material may be poured-in-place concrete, precast concrete grids, or modular unit pavers. The pervious material may support grass or other vegetation.

Gravel / Crushed Rock

Gravel and crushed rock can make acceptable surfaces provided the supporting base is properly designed. This may include a geotextile, geogrid, or combination of the two.

APPENDIX C

ILLUSTRATIONS

Figure C-1

Typical Unplanned Emergency Drainage Route

Unplanned Emergency Drainage Route (EDR). The CB inlet is located at the low point of a cul-de-sac. Under 100 year runoff conditions, or under conditions where the inlet becomes blocked (debris and/or hail), the runoff will enter the house which is downstream of this location.

Sample Maximum Level Gauge

OTT Maximum Level Gauge

Maximum level gauge with exchangeable color tape

The maximum level gauges show the highest surface water level by color marking. They are maximum level indicators for preservation of evidence and offer exact data for a later treatment of a flood event.

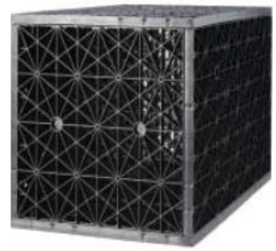
In a measuring cylinder made of safety glass there is a 1 m long glass-fiber reinforced plastic measuring rod with cm-E-partition and dm-numbering. A transparent self-adhesive color band is fixed on the measuring rod.

The rising water in the measuring cylinder rinses the color out reliably, up to the respective water level. A sharp dividing line displays the highest water level.

The exchange of the color band is easily done via loosening the upper cylindrical head screw.

Atlantis Stormwater Management System

The Atlantis underground tank system is a modular sub surface system that can be constructed to hold any volume required. The sub surface location of the tank frees up space for landscaping or driveway use while also ensuring optimal conditions for retaining water is always maintained. All macro and micro pollutants are completely kept out of the system through an Atlantis Filtration Unit.

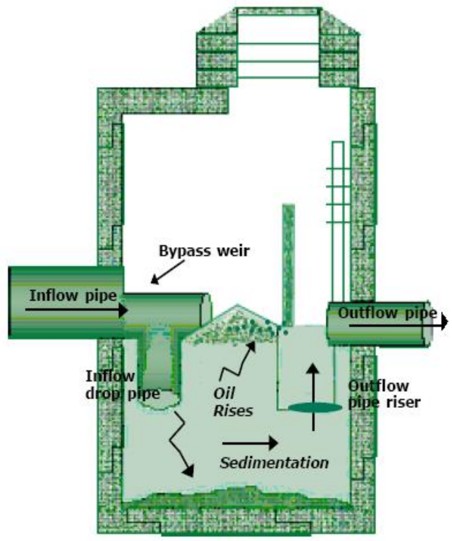


Matrix® tank module

URL: http://www.atlantiscorp.com.au/Home

Stormceptor

The Stormceptor® is a stormwater separator that efficiently removes grit, fine sediment and free oil from stormwater. These pollutants are stored inside a treatment chamber for safe and easy removal. Stormceptor® protects lakes, rivers, streams and coastal areas from hazardous material spills and daily stormwater runoff pollution. The In-line Stormceptor® is a unique solution because of its patented internal by-pass. This prevents the re-suspension and scouring of trapped pollutants during infrequent high flow periods.



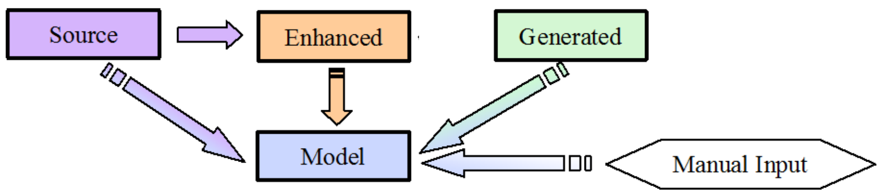
- Stormwater flows into the upper by-pass chamber via the storm sewer pipe.
- Low flows are diverted into the lower treatment chamber by a weir and drop tee/orifice assembly.
- The drop tee/orifice assembly will discharge water parallel to the lower treatment chamber wall.
- Flows in access of the drop tee/orifice assembly capacity will flow over the weir and into the downstream sewer.
- Surcharged water will create a backwater effect on the riser pipe and the head differential between the drop tee/orifice assembly and outlet riser pipe will decrease.
- This prevents large flows entering the treatment chamber and scouring any trapped pollutants.
- Oils and other liquids with a specific gravity less than water will be trapped underneath the fiberglass insert.
- Sediment will settle to the bottom of the chamber by gravitational forces.
- The circular design of the treatment chamber is designed to prevent turbulent eddy currents and to promote settling.
- The riser pipe is downstream of the by-pass chamber and is connected to the downstream sewer pipe.
- Water flows up through the riser pipe based on the head at the inlet weir

APPENDIX D

Data Dictionary

Model and GIS Data Summary

The data contained in the InfoSWMM & GSSHA models were generated from various datasets. Datasets are considered to be a combination of both spatial (drawing) and attribute (information) data, and were, in this case, managed using ESRI GIS tools. As shown below, these datasets were either; supplied directly from the District of Summerland and used as supplied or modified as required, created from existing or collected field information, or in some cases, generated from assumptions.



The following are definitions of how the information was used or modified in order to generate the model.

Source: Data that was directly imported into the model, either supplied by the district or other sources, but with no changes or additions to the data.

Enhanced: A dataset that was supplied, but which was either edited to correct errors, or supplemented with additional information. These enhancements could be either spatial or attribute based, or both.

Generated: A dataset that was created by USL.

Manual Input: Data that was manually entered into the model.

The table following is a list and description of the files used in the creation of the InfoSWMM & GSSHA models or in the figures supplied in the report. Files that were supplied by the District of Summerland and were unmodified are not listed.

ESRI Shape file (.SHP)

Shapefile Name	Data Type	Definition	Path
0872-parcel-database.shp	Source	Cadastral layer	GIS\Data\Cadastral
Municipal_Boundary.shp	Source	Municipal Boundary	GIS\Data\Cadastral
2009_02_10_All_Catchments.shp	Created	Primary Catchments for study area	GIS\Data\Catchments\GSSHA Model Boundaries
BR_Mask.shp	Created	Polygon highlighting Bentley Road Catchment. Similar masks exist for every catchment, with the prefix of the file name corresponding to the catchment name.	GIS\Data\Catchments
FA_Lines_by_basin.shp	Created	Lines depicting the natural overland flow paths	GIS\Data\Hydrology\Shp
2008_10_20NewFlowAccumulation.shp	Created	Lines depicting the natural overland flow paths, but snapped to existing infrastructure and known flow paths.	GIS\Data\Hydrology\Shp
ProjectCatchments.shp	Created	Primary and Sub Catchments for study area	GIS\Data\Hydrology\Shp
Curbs_Drainage_Lines.shp	Created	Data set created from field investigation containing information pertanent to curb locations/types.	GIS\Data\Infra\Drainage
2008_10_17Drainage_Inventory_pts.shp	Enhanced	File showing location of drainage features in point form (CB, MH, Outfall, Dry Well, etc). Created from existing CADD drawing and supplemented with updated information	GIS\Data\Infra\Drainage
SummaryLines.shp	Enhanced	Lines showing culverts, channels, and pipes for entire study area, existing and proposed. Creating from multiple sources.	GIS\Data\Infra\Drainage
roads.shp	Source	Road network	GIS\Data\Infra\Roads
PrimaryRoads.shp	Enhanced	Primary road network extracted from roads.shp	GIS\Data\Infra\Roads
alr.shp	Source	ALR polygons for study area	GIS\Data\Landuse

Shapefile Name	Data Type	Definition	Path
SummSoils.shp	Source	Soils data	GIS\Data\Soils\Shps
Contours_5m.shp	Created	5 meter contours created from DEM. 50cm, 1m, and 20m contours also exist in this folder.	GIS\Data\Topography\Contours
Hillshade-Image.ecw	Created	Raster file depicting terrain, enhanced by shadows to provide 3D feel.	GIS\Data\Topography\Hillshade
lakes.shp	Source	Lake polygons	GIS\Data\Water_Features
sr1m_cutfill_poly.shp	Created	Polygon layer depicting surface depressions	GIS\Data\Hydrology\Shp
Figure5Creeks.shp	Enhanced	Creeks layer used in figures	GIS\Data\Water_Features
DEV_AREAS_MDP2 only.shp	Created	Existing and future development areas	GIS\SHP
0872-parcel-database.shp	Source	Cadastral layer	GIS\Data\Cadastral
*Note: There may be more files used in the figures than are explained here. Any files not shown above are either variations of the files above, or are for cosmetic purposes in the figures. In any case, all necessary files for recreating the figures will be sent, other than the orthophotos and Digital Elevation Model.			

PHASE 1 – PRAIRIE VALLEY INFOSWMM MODEL

The files that were used to create the model were one of three types.

1. ESRI Shape file (.SHP)
2. AutoCADD (.DWG)
3. Database (.DBF)

Once the data goes through one of the three processes either modified, source or enhanced. All the data is then processed into a geo-database which is created and up dated by InfoSWMM (GIS Gateway)

The model data can be found in the geo-database or mdb file, however only the general information about the object is stored in this file, the actual model results and input information is stored in a separate database which is linked to the geo-database through the InfoSWMM extension which requires a ARCMAP 9.x license.

AutoCADD (.DWG)

- Depressions.dwg
  - Created from the digital contour information that was supplied
- Sub-Catchments.dwg
  - Created by USL, however the information and data was modified in InfoSWMM

Database (.DBF)

- AUC-DU.dbf
  - Unit design values based on land use
  - \GIS\Data\Parcels

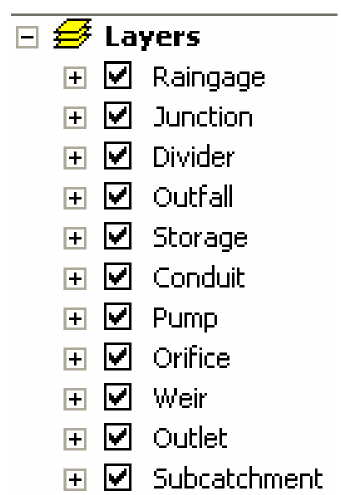
The following is a list of MS Excel spreadsheets used to generate tables in the report for Phase 1.

MS Excel (.XLS)

- Table B-X-X Subcatchments.xls
  - Contains runoff volumes for each of the sub-catchments in Phase 1 – Prairie Valley.
  - \Tables
- Summary Tables - Prairie Creek.xls
  - Contains characteristics of existing and future sub-catchments and links for Phase 1.
  - Used to Create Tables 5.1-1 and 5.1-2 in the report.
  - \Tables\Summary Tables

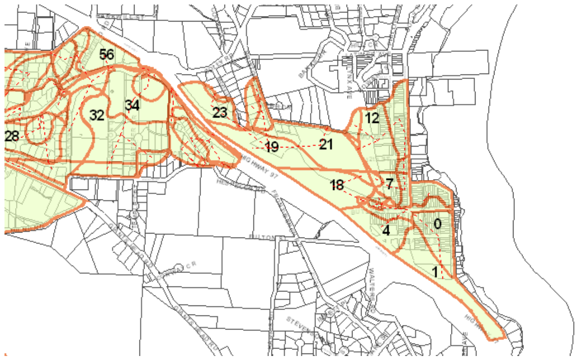
InfoSWMM Files (Geo-Database)

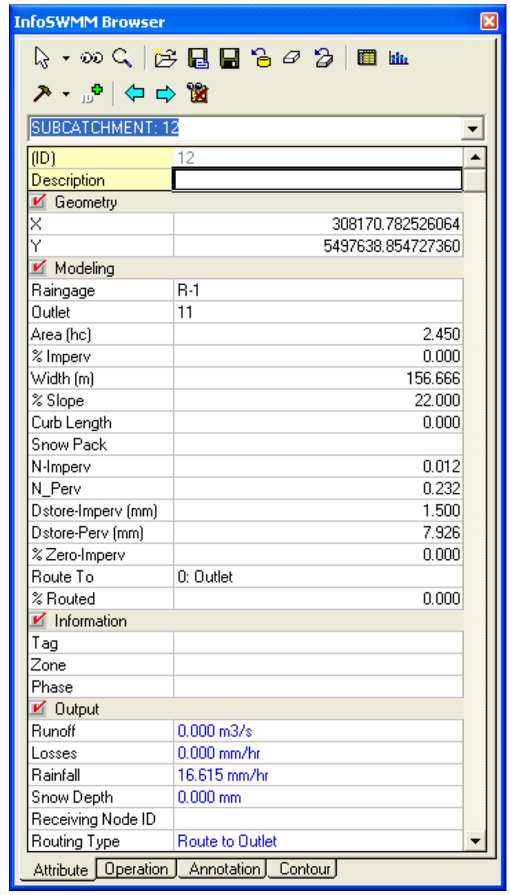
All information regarding the layers listed can be found in the following location …\GIS\Model\Drainage-Model.ISDB\Map\Map.mdb. The files are contained in a single MDB file, these can be extracted into a single SHP and joined to an exported InfoSWMM DBF.



The following are examples of the MDB file created by the INFOSWMM model. The subcatchments, Junctions and Conduits are major components of the model, also contained is a description of the information and displayed.

SUB CATCHMENTS




InfoSWMM Browser

SUBCATCHMENT: 12

(ID)	12
Description	
Geometry	
X	308170.782526064
Y	5497638.854727360
Modeling	
Raingage	R-1
Outlet	11
Area (hc)	2.450
% Imperv	0.000
Width (m)	156.666
% Slope	22.000
Curb Length	0.000
Snow Pack	
N-Imperv	0.012
N_Perv	0.232
Dstore-Imperv (mm)	1.500
Dstore-Perv (mm)	7.926
% Zero-Imperv	0.000
Route To	0: Outlet
% Routed	0.000
Information	
Tag	
Zone	
Phase	
Output	
Runoff	0.000 m3/s
Losses	0.000 mm/hr
Rainfall	16.615 mm/hr
Snow Depth	0.000 mm
Receiving Node ID	
Routing Type	Route to Outlet

Attribute | Operation | Annotation | Contour

The Sub catchments were created by USL, they were then split using the soils classification data. Additional information was added to each catchment (Slope/Width and Area). The resulting data was imported in the model.

Purpose:

Subcatchments are hydrologic units of land whose topography and drainage system elements direct surface runoff to a single discharge point. The user is responsible for dividing a study area into an appropriate number of subcatchments, and for identifying the outlet point of each subcatchment. Discharge outlet points can be either nodes of the drainage system or other subcatchments (infoSWMM)

Process:

Created by Urban Systems Ltd, enhanced with Soils data which was supplied by the District of Summerland.

Source File - Catchments.shp

Files & Format:

ESRI Shape file and Geodatabase

Data Type: Personal Geodatabase Feature Class

Location: …….\HMVDB1\Map\Map.mdb

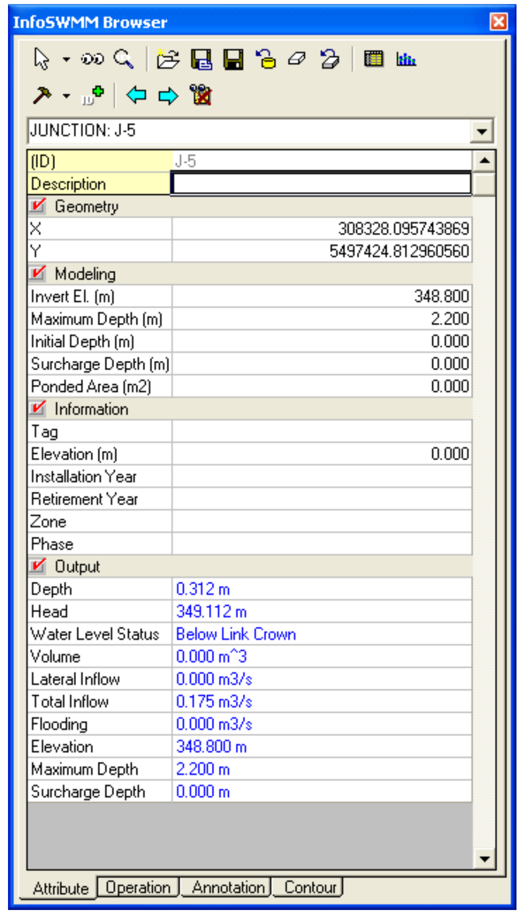
Feature Dataset: Network

Feature Class: Subcatch

Feature Type: Simple

Geometry Type: Polygon

JUNCTIONS



Purpose:

Junctions are drainage system nodes where links join together (infoSWMM)

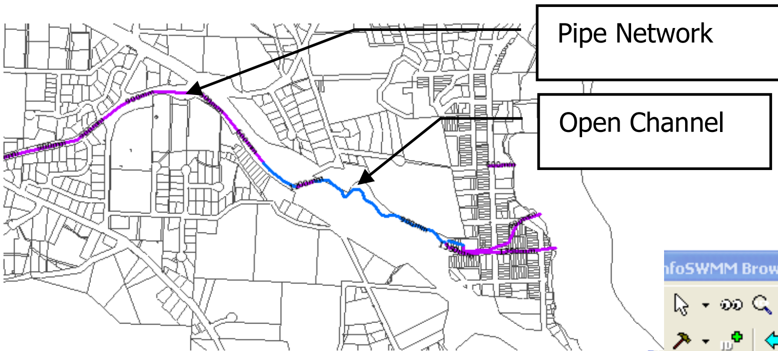
Source:

Created from Storm – Nodes, the dataset was enhanced from as built information and manual imput.

Type:

Type: Personal Geodatabase Feature Class
Location: …….\HMVDB1\Map\Map.mdb
Feature Dataset: Network
Feature Class: Junction
Feature Type: Simple
Geometry Type: Point

CONDUITS



Purpose:

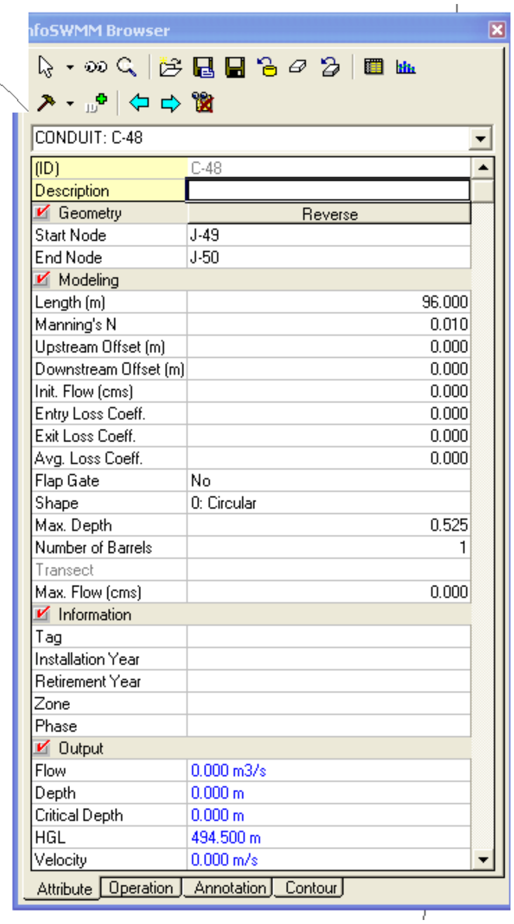
Conduits are pipes or channels that move water from one node to another in the conveyance system (infoSWMM)

Source:

Created from Storm – Conduits, the dataset was enhanced from as built information and manual pipes/channels were added.

Type:

Data Type: Personal Geodatabase Feature Class
Location: …….\HMVDB1\Map\Map.mdb
Feature Dataset: Network
Feature Class: Conduit
Feature Type: Simple
Geometry Type: LineType:

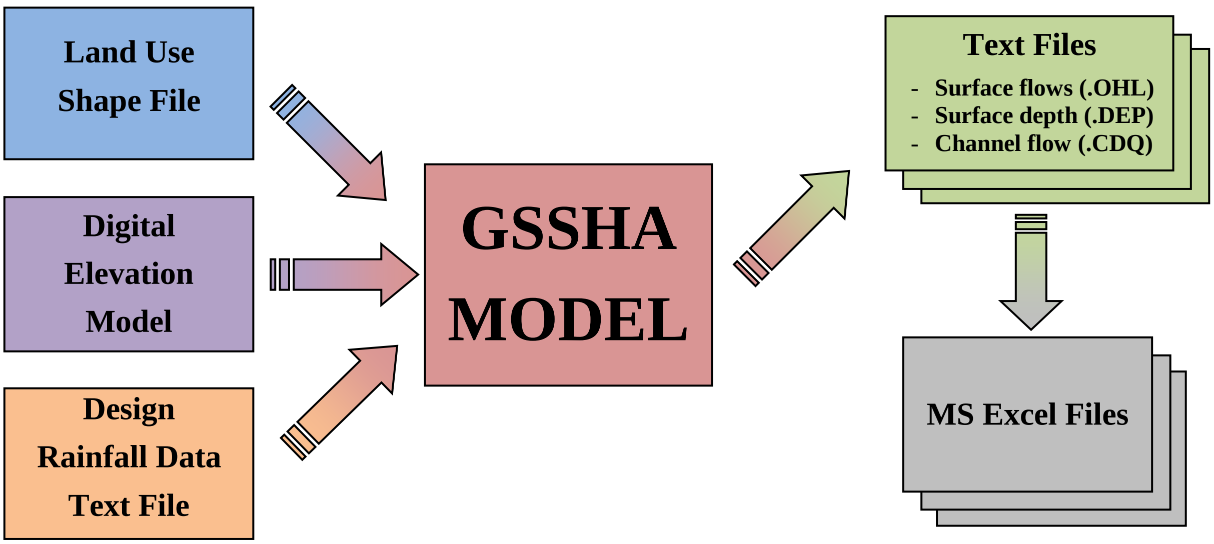


PHASE 2 - MODEL AND GIS DATA SUMMARY

The files that were used to create the GSSHA model were one of three types.

1. ESRI Shape file (.SHP)
2. Digital Elevation Model (.RRD)
3. Text file (various extensions)

The Land Use input files make up the crucial input data elements as it defines the conditions to which the rainfall interacts with the surface i.e. the Digital Elevation Model which was provided by the District. The rainfall data text files provide the model a breakdown of the 100 year design storm intensities over the duration of concern. These files offer little value on their own and have such been excluded from the supplied dataset. The GSSHA model produces an array of output text files ranging from infiltration volumes to channel flows and hydrographs. The primary output for this investigation were the peak flows through existing stormwater inventory and areas with significant surface water accumulation. The relevant information from these text files was extracted into MS Excel for analysis and summary. Offering little significance in their native format these result files like the rainfall data have been excluded from the supplied dataset.



The following is a list and description of the files used in or created from the model that are included in the dataset provided to the District. Files that were supplied by the District of Summerland and were unmodified are not listed.

ESRI Shape file (.SHP)

- All_Landuse.shp (\GIS\Data\Landuse\Existing Landuse for Figures\)
    - Created from a combination of:
        - SWMLandUse_E.shp, a polygon shape file of official land uses in Summerland provided by the District
        - Modified du.shp, a point shape file of all inhabited buildings in Summerland provided by the District
- 2009_01_28_Intersect_FutureExistingLanduse_Subcatchments.shp (\GIS\Data\Landuse\Future Land Use\)
    - Created from a combination of:
        - Future_Land_Use.shp, a polygon shapefile identifying future development areas with anticipated land uses.
        - All_Landuse.shp, a polygon shapefile containing existing land use.
        - ProjectCatchments.shp, a polygon shapefile containing Primary and Sub Catchments for study area

MS Excel file (.XLS)

- Capital Costs Estimates – CNV.xls (\Tables\)
  - Contains Conventional capital costs for each of the identified projects in Phase 2
  - Created by USL based upon information in SummaryLines.shp
- Capital Costs Estimates – DEF.xls (\Tables\)
  - Contains capital costs for each of the identified Existing Deficiency projects in Phase 2
  - Created by USL based upon information in SummaryLines.shp
- Capital Costs Estimates – LID.xls (\Tables\)
  - Contains Low Impact Development capital costs for each of the identified projects in Phase 2
  - Created by USL based upon information in SummaryLines.shp
- Table 6_1 Capital Costs Summary.xls (\Tables\)
  - Contains a list of all the identified projects (Phase 1 & Phase 2) with a breakdown of how the capital costs are allocated.
  - Used to create Table 6.1 - Capital Costs Estimate Summary in the report.
- Summary Tables-All Catchments.xls (\Tables\Summary Tables\)
  - Contains characteristics of existing and future sub-catchments and links for Phase 2 area.
  - Based upon information in All_Landuse.shp, 2009_01_28_Intersect_FutureExistingLanduse_Subcatchments.shp and SummaryLines.shp.

APPENDIX E

Drainage Inventory
(Prairie Creek Basin)

Point ID – 10   ALICE ST. @ MITCHELL AVE. (North side)

Photo Number – 1

Point ID – 20 MITCHELL AVE.

Photo Number – 2

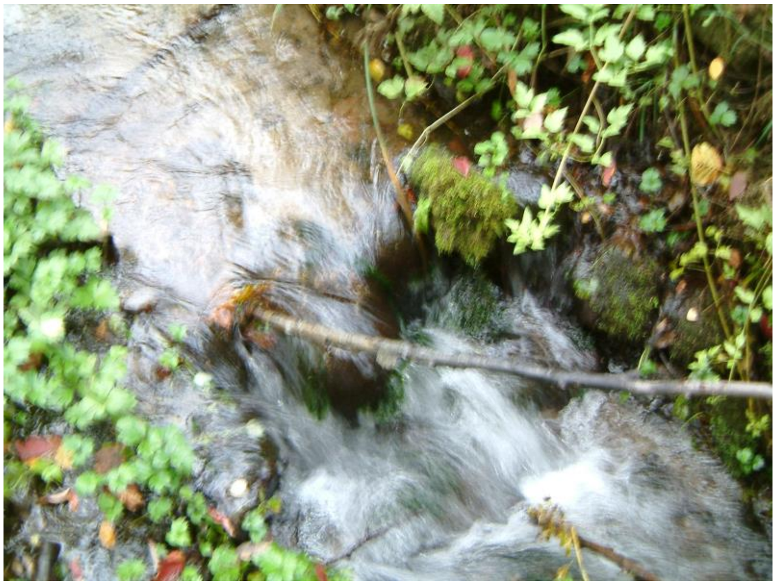
(West side)

Photo Number – 3

(West side)

Point ID – 20   MITCHELL AVE.

Photo Number – 4



West side

Photo Number – 5

East side

Point ID – 20   MITCHELL AVE.

Photo Number – 6

East side

Point ID - 30

NO PHOTO

Point ID – 40 LISTER AVE.
Photo Number – 7

(West side)

Photo Number – 8

(East side)

Point ID – 45 DALE MEADOWS RD.

Photo Number – 67

(North side)

Photo Number – 68

(North side)

Point ID – 50 RUTHERFORD ST.

Photo Number – 9

(West side)

Photo Number – 10

(East side)

Point ID – 55 PRIARIE VALLEY ROAD AND MORROW

Photo Number – 42

(North side – looking north)

Photo Number – 41

(North side – looking south)

Point ID – 55   PRAIRIE VALLEY ROAD AND MORROW

Photo Number – 43

(South side – looking south)

Photo Number – 44

(South side – looking south)

Point ID – 60 DALE MEADOWS RD.- EAST OF RIPPEN AVE.

Photo Number – 11

(North side)

Photo Number – 12
South Side

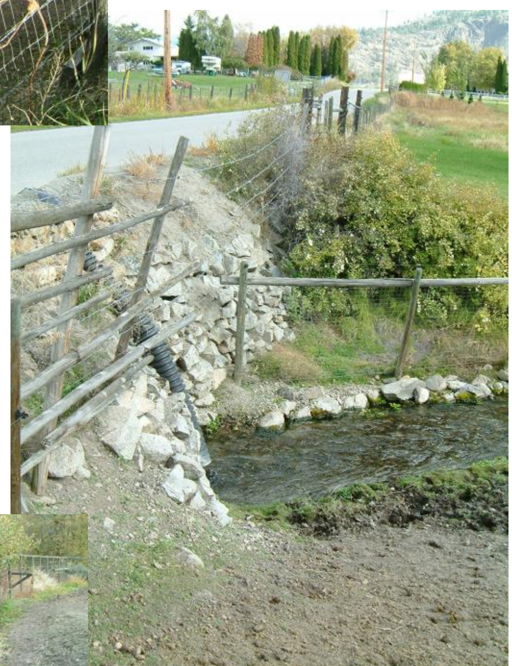


Photo Number – 13

(South side)

Point ID – 65   DALE MEADOWS RD

Photo Number – 65

North side – looking west

Point ID – 70 HADDRELL AVE. @ BARNES AVE.

Photo Number – 14

West side

Photo Number – 15

West side

Point ID – 70   HADDRELL AVE. @ BARNES AVE.

Photo Number – 17

West side – looking east

Photo Number – 16

West side – looking east

Point ID – 70   HADDRELL AVE. @ BARNES AVE.

Photo Number – 17

East side

Photo Number – 18

East side

Point ID – 75 DALE MEADOWS RD. - EAST OF LUMSDEN AVE

Photo Number – 61

West side

Point ID – 80 LUMSDEN AVE. @ DALE MEADOWS RD.

Photo Number – 19

South side

Photo Number – 20

North side

Point ID – 85 DALE MEADOWS RD. - EAST OF LUMSDEN AVE

Photo Number – 57

North side

Photo Number – 60

North side –
Looking North

Point ID – 90 SINCLAIR RD.

Photo Number – 37

West side – Looking West

Photo Number – 21

West side

Point ID – 90 SINCLAIR RD.

Photo Number – 22

East side

Photo Number – 39

East side – Looking East

Point ID – 100 DALE MEADOWS BALL PARK & GIANTS HEAD SCHOOL

Photo Number –23

West side

Photo Number –24

East side

Point ID – 105   DALE MEADOWS BALL PARK

Photo Number –56

South side

Point ID – 109   GIANT'S HEAD SCHOOL

Photo Number –51

Photo Number – 49
Looking South

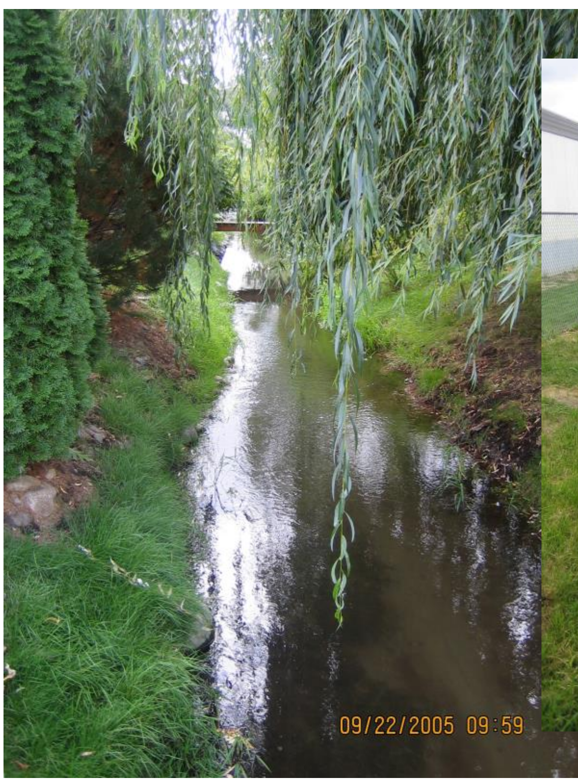


Photo Number – 50
Looking North

Point ID – 110 PRAIRIE VALLEY RD. @ GIANT'S HEAD SCHOOL

Photo Number –26

South side

Point ID – 120   PHINNEY AVE.

Photo Number –27

East side

Photo Number –28

East side

Point ID – 130 SAUNDERS CRES. EAST

Photo Number –31

West side – Looking West

Photo Number –29

West side

Point ID – 130 SAUNDERS CRES. EAST

Photo Number –30

East side

Photo Number –33

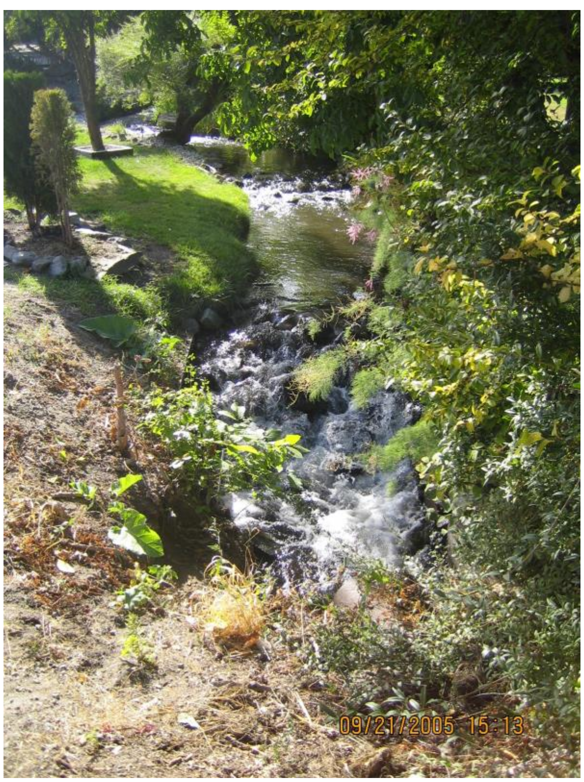
East side – Looking East

Point ID – 140 VICTORIA RD. SOUTH

Photo Number –32

West side

Photo Number –35



West side – Looking West

Point ID – 150 PRAIRIE VALLEY RD. @ BROWN ST.

Photo Number –33

East side

Photo Number –26

East side

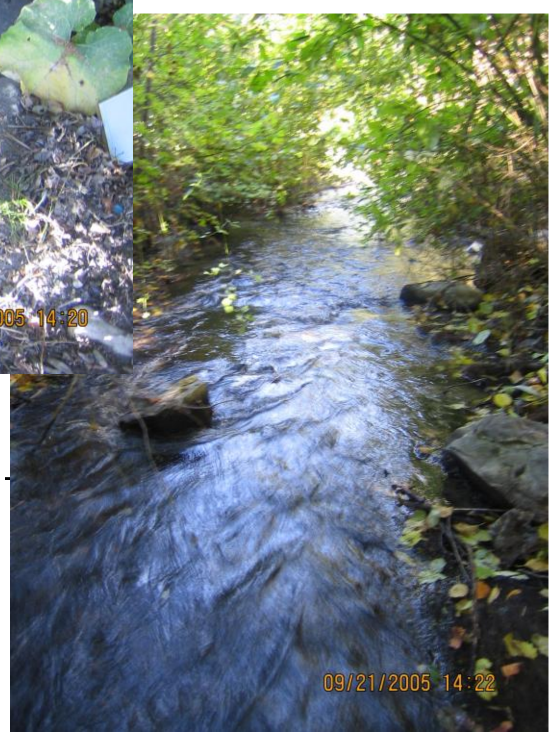


Photo Number -

East side – Looking East

Point ID – 160 SUB-STATION ON PRAIRIE VALLEY RD.

Photo Number –34

South side

Photo Number –29

South side

Point ID – 170 HIGHWAY 97 @ BRISTOW RD.

Photo Number –35

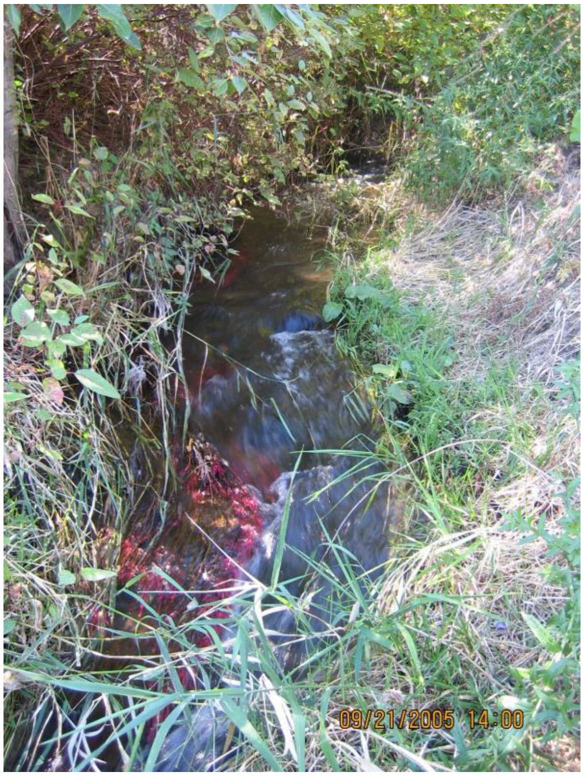
North side

Photo Number –36

North side

Point ID – 170   HIGHWAY 97 @ BRISTOW RD.

Photo Number –24



North side – Looking North

Photo Number –25

North side

Point ID – 170 HIGHWAY 97 @ BRISTOW RD.

Photo Number –12

South side

Photo Number –13

South Side – Looking South

Point ID – 175 HIGHWAY 97 TO BULTER ST. INTAKE

Photo Number –15

East Side of Hwy 97
Looking West

Photo Number –16

Photo Number –11

Point ID – 180   BUTLER ST. INTAKE

Photo Number –37

Photo Number –10

Photo Number –9

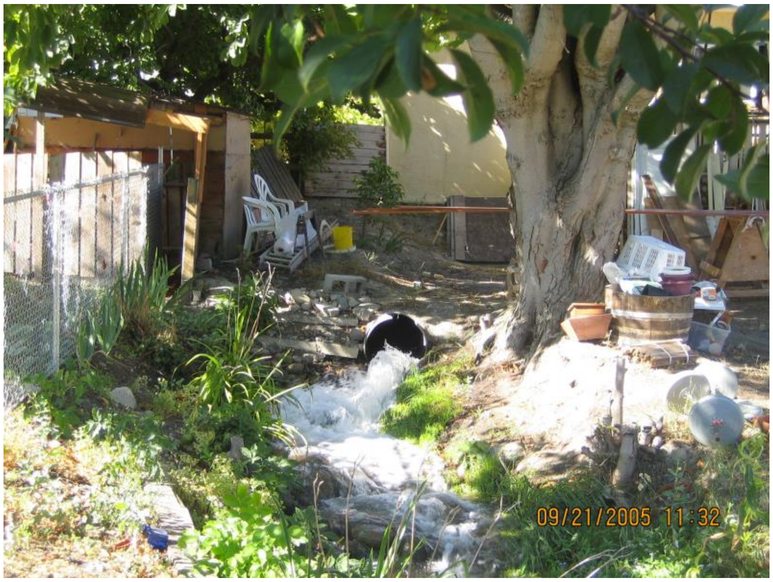
East Side –
Looking East

Point ID - 185

Point ID - 185

Point ID – 185 SHAUGHNESSY AVE

Photo Number –6



West side – Looking West

Photo Number –7

East side

Point ID – 190 LAKESHORE DR. SOUTH

Photo Number –4

South Side – Looking South

Photo Number –40

South side

Point ID – 200 LAKESHORE DR. SOUTH

Photo Number –41

North side

Photo Number –42

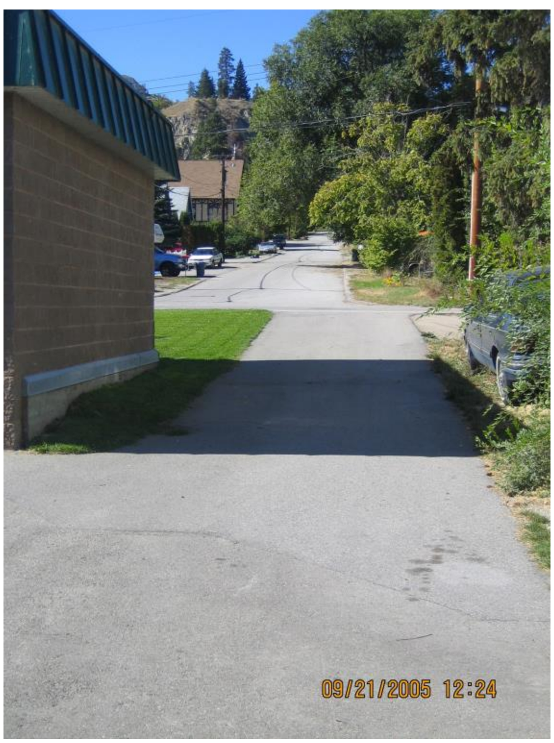
North side –
Looking East

Point ID – 205 BUTLER ST. OUTFALL

Photo Number –17

East Side – Looking East

Photo Number –18



East Side – Looking West

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