## 5.2 Environmental Protection and Enhancement

Specific engineered stormwater treatment recommendations to meet environmental objectives are discussed in the previous infrastructure section. This section focuses on environmental protection and enhancement activities other than those that are infrastructure related.

- **Tree canopy**

One of the most basic things that could be done to improve stormwater management is to increase the amount of tree cover in White Rock. In 2005, the City Green model was used to estimate tree cover in White Rock (based on 2002 images) and found that 15% of White Rock was treed. Given that White Rock is nearly at build-out, these results are not surprising and are in line with tree cover in other Metro Vancouver municipalities[5].

Increasing the amount of tree cover would provide benefits to stormwater management in terms of both volume and quality. Various studies have shown the rainfall interception of trees to be significant, but highly variable because it is dependant on many factors. However, the general findings are that trees play an important role in intercepting rainwater, both through the roots and through interception in the canopy itself. A study conducted in North Vancouver measured the amount of rain intercepted by Douglas Fir and Western Red Cedar, and found that the average interception rate was 49% for Douglas Fir and 61% for red cedar[6]. Trees also provide other benefits such as helping to purify the air and water. Further study is currently taking place at the University of British Columbia, however results of that study are not yet available.

Tree roots are quite adept at finding their way through soil to seek essential air and water. Consequently, they will break up tight soils and improve infiltration to some extent. In many dense urban situations, trees cannot sustain the energy required to do this in barren, tight, airless and dry "soils" and die, often within a few years. Structural soils are one solution to provide some balance between supporting pavements and trees. The voids between open graded aggregate particles hold un-compacted soil that allows water, air and roots to move more easily. Soil conditions are, however, irrelevant if water and air cannot reach the soil/root zone. Impervious pavements send water to the storm sewer and irrigation (subsurface drip usually) adds a lot of (often unnecessary) expense and maintenance. Permeable pavements, infiltration swales, etc. can be an effective part of the solution to manage rainwater, improve water quality and support healthy urban trees plantings.

[5] Hyland Creek watershed in Surrey (26%); Maple Ridge Town Centre (20%); Still Creek watershed in Vancouver and Burnaby (12%) Source: AXYS Environmental Consulting Ltd. 2006. Assessment of Regional Biodiversity and Development of a Spatial Framework for Biodiversity Conservation in the Greater Vancouver Region. Prepared for the Greater Vancouver Regional District, Burnaby, BC.

[6] Asadiany, Y and M. Weller. 2009. A new approach in measuring rainfall interception by urban trees in coastal British Columbia. Water Quality Research Journal of Canada. 44:16-25.

It is suggested that the City consider an urban tree planting program and set firm targets for tree canopy cover. Since stormwater interception is about twice as high for coniferous trees compared to deciduous trees,[7] the tree planting program should encourage planting of conifers wherever possible.

- **Marine and freshwater habitat restoration**

As discussed below, there are a few opportunities for restoration of marine and freshwater habitat that could be pursued in the future, but are not suggested as priority items at this stage.

Current concerns about ocean survival of salmonids have led to interest in the role of forage fish such as surf smelt and sand lance, which are important prey for many fish and bird species. A study into forage fish habitat in Boundary Bay identified opportunities to protect and enhance habitat for these species[8]. The West Beach boat ramp to the White Rock pier and the area around the "Rock" are two locations where recommendations were made to replace gravels and coarse sand for forage fish spawning, and to plant native vegetation to shade the upper intertidal area and improve juvenile survival[9].

Another recommendation is to improve access from Semiahmoo Bay to Coldicutt Creek to enable salmon to enter and colonize the lower portion of the stream. Prior to undertaking such a project, water quality, flows and the benthic invertebrate community (food supply) would need to be assessed to confirm that conditions are suitable for salmonids. Physical restoration would include improving access from the beach through the rail crossing culvert into the lower portion of the creek (the creek currently empties through a culvert under the rail bed and splashes onto rocks at the beach, with access to the culvert only during high tide) and improving habitat upstream of the culvert (complexing with large boulders and woody debris, removal of garbage, removal of invasive Himalayan blackberry and replacement with native vegetation).

Both of these recommended habitat restoration initiatives may be candidates for implementation through local stewardship groups working with the City. Given their lower relative priority, at this time, it is not recommended that specific funds be allocated directly by the City.

Appendix B includes further information on these Environmental Protection and Enhancement recommendations.

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[7] Llorens and Domingo 2007 as cited by Asadiany, Y and M. Weller. 2009. A new approach in measuring rainfall interception by urban trees in coastal British Columbia. Water Quality Research Journal of Canada. 44:16-25.

[8] de Graf, R.C. 2007. Friends of Semiahmoo Bay Society Marine Conservation Initiative Boundary Bay Intertidal Forage Fish Spawning Habitat Project Summary of the Project and Findings July 2006 – October 2007. Prepared for Friends of Semiahmoo Bay Society Marine Conservation Initiative. Prepared by Emerald Sea Research & Consulting.

[9] Ibid.

**Table 8: Recommended Environmental Protection and Enhancement Initiatives**

| Recommendation | Benefits | Cost Estimate |
|---|---|---|
| **Urban tree planting program**<br><br>Develop an urban tree planting program that addresses both private and public lands, with demonstrated linkage to the Tree Management Bylaw. | Increasing the amount of tree cover would provide benefits to stormwater management in terms of both volume and quality. Trees play an important role in taking up stormwater, both through the roots and through interception in the canopy itself. A study conducted in North Vancouver measured the amount of rain intercepted by Douglas Fir and Western Red Cedar, and found that the average interception rate was 49% for Douglas Fir and 61% for Red Cedar. | $25,000-$35,000 |
| **Shoreline restoration (at West Beach boat ramp to pier; and near the rock)**<br><br>Replace gravels and coarse sand for forage fish spawning and plant native vegetation to shade the upper intertidal area and improve juvenile survival. | Enhancing and protecting habitat for forage fish (such as surf smelt and sand lance) would promote survival of salmonids and birds, which both prey on forage fish. | Review opportunities for cost sharing and implementation by local stewardship groups working with the City. |
| **Improved fish access to Coldicutt Creek**<br><br>Physical restoration would include improving access from the beach through the rail crossing culvert into the lower portion of the creek and improving habitat upstream of the culvert (complexing with large boulders and woody debris, removal of garbage, removal of invasive Himalayan blackberry and replacement with native vegetation). | Improving access from Semiahmoo Bay to Coldicutt Creek would enable salmon to enter and colonize the lower portion of the stream. Prior to undertaking such a project, water quality, flows and the benthic invertebrate community (food supply) would need to be assessed to confirm that conditions are suitable for salmonids. | Review opportunities for cost sharing and implementation by local stewardship groups working with the City. |

## 5.3 Planning and Analysis

ISMPs often recommend planning and analysis activities to monitor change and gather more detailed information that may be needed for future implementation steps. This ISMP recommends considering additional aquifer mapping, establishing water quality targets for the aquifer, and monitoring watershed health.

### Aquifer Protection

- **Aquifer mapping**

Additional field investigation may be needed to better map and quantify aquifer vulnerability. Mapping will more specifically identify areas suitable for infiltration based water quality treatment systems for paved surfaces by better understanding potential aquifer vulnerability. Before taking any action (if required), the City should consult with EPCOR to first understand the scope of their commissioned study and consider the need for deeper investigation to support decisions. It is not expected that a specific mapping study will be undertaken by the City, but rather by EPCOR and through project-by-project geotechnical investigations during land development and road reconstruction preliminary design initiatives.

- **Water quality targets for the aquifer**

The City should consider strengthening communications with EPCOR with respect to water quality conditions and performance targets for the aquifer. Establishing water quality targets for the aquifer would allow the City and its residents to be aware of conditions of the aquifer. This information would also provide EPCOR with useful data for conducting their own future studies, and to reach a common understanding between the two parties with respect to land use and infrastructure management decisions.

### Environmental Protection

An ISMP typically includes indicators of watershed health to assess current conditions and provide a baseline for future monitoring. White Rock differs from many jurisdictions in Metro Vancouver as it lacks fish bearing streams (White Rock has only three remnant streams, none of which are fish bearing), and stormwater discharges directly to the marine environment. Given the lack of streams, the most relevant indicators of watershed health are:

- **Watershed health indicator: Impervious area –** The Metro Vancouver ISMP template uses total impervious area (TIA), or where available, effective impervious area (EIA)[10] as an indicator of watershed health, as they can be measured over time, related to ISMP objectives, and addressed in municipal planning processes. Strategies to reduce imperviousness and increase infiltration on private and public property will reduce the overall volume of runoff, which in turn should improve runoff water quality in White Rock.

[10] Total impervious area provides a measure of how much land is covered by impermeable structures. Effective impervious area provides a measure of how much the impervious surfaces are directly connected to the drainage system (streams and storm drains).

- **Watershed health indicator: Tree canopy cover –** An indicator of tree canopy is relevant to stormwater management because trees play an important role in taking up stormwater, both through the roots and through interception in the canopy itself. The role of trees is increasingly being recognized economically as well as environmentally.

- **Watershed health indicator - Fecal coliform levels in Semiahmoo Bay –** Water quality in Semiahmoo Bay reflects activities on land and is often a concern in areas that receive stormwater. Physical parameters (temperature, conductivity, pH, dissolved oxygen, turbidity), bacteria, nutrients and metals can provide evidence of degraded water quality due to human influences. Discharge from the marine outfalls is greatly diluted when it enters Semiahmoo Bay and is dispersed by tidal action and currents. This high dilution can make it difficult to measure changes in many of the parameters typically used to assess effects of runoff on receiving environment water quality. However, fecal coliform bacteria is one type of contaminant that has been tracked for many years due to its relevance to human health, both for swimmers and for consumption of shellfish.

  Fecal coliform contamination can be due to many sources, including polluted stormwater (which carries waste from pets and wildlife), septic systems, and cross connections with the sanitary sewer system. Monitoring of fecal coliforms can be coordinated with the BBAMP. The BBAMP is a multi-agency partnership that was developed in 2009 to provide a baseline measure of ambient water quality, sediment quality and biota in Boundary Bay. Future monitoring should be able to demonstrate whether or not efforts to improve overall environmental quality (e.g., via implementing ISMPs by White Rock and other municipalities) are having the desired effects.

More information on these indicators is included in Table 9 below and Appendix B.

**Table 9: Watershed Health Indicators for White Rock ISMP**

| Indicator | Type of Indicator | Baseline Status | Potential Target | Ability to Update Status |
|---|---|---|---|---|
| Impervious cover | Land development, ability of land to infiltrate rainwater | 56% TIA<br>43% EIA | No increase in EIA | Can be assessed annually using zoning information |
| Tree canopy cover | Amount of urban tree cover, ability of trees to intercept rainwater | 15% (2002 images) | To be developed with City | Metro Vancouver will update in 2010 using 2009 images |
| Fecal coliform levels in Semiahmoo Bay | Indicator of water quality, influenced by stormwater discharges and other sources | No beach closures since at least 1993 | No beach closures | Assess and report annually |

**Table 10: Recommended Planning and Analysis**

| Recommendation | Benefits | Cost Estimate |
|---|---|---|
| **Map aquifer vulnerability**<br>Additional field investigation may be needed to better map and quantify aquifer vulnerability. Before suggesting any action by the City, we suggest continued dialogue with EPCOR to first understand the scope of their commissioned study and consider the need for deeper investigation to support decisions. It is not expected that a specific mapping study will be undertaken by the City, but rather by EPCOR and through project-by-project geotechnical investigations during land development and road reconstruction preliminary design initiatives. | Mapping will more specifically identify areas suitable for infiltration based water quality treatment systems for paved surfaces by better understanding potential aquifer vulnerability. | In house costs |
| **Watershed health indicators**<br>Implement and track the following watershed health indicators:<br>• EIA (effective impervious area)<br>• Tree canopy cover<br>• Fecal coliform levels | Tracking watershed health over time will help identify successes and areas for improvement. | In house costs to participate in the BBAMP, plus $10,000 every 5 years for reassessing tree canopy and impervious area indicators |

## 5.4 Policy and Regulations

Most municipalities, including the City of White Rock, implement regulations that directly affect stormwater management (e.g., OCP and Zoning Bylaws). However, few municipalities explicitly consider how land use and development practices relate to stormwater management when developing their bylaws and regulations. The City's following bylaws and policies are relevant to stormwater management.

- OCP
- Environmental Strategic Plan
- Parks Master Plan
- Neighbourhood plans
- Density Bonusing Policy
- Town Centre Design Guidelines
- Duplex Design Guidelines
- Zoning Bylaw
- Building Bylaw
- Subdivision Bylaw
- Cosmetic Pesticide Use Bylaw
- Tree Management Bylaw
- Development Cost Charges Bylaw
- Drainage Utility User Fee Bylaw

These policies and regulations were reviewed to identify key areas in which provisions related to stormwater could be strengthened.

- **Zoning Bylaw -** The City's Zoning Bylaw already includes provisions to establish maximum lot coverage regulations, which help limit impervious area. However, the City may consider amending its Zoning Bylaw to establish more specific requirements to limit impervious area and protect open space.

  For example, the City could set maximum as well as minimum parking standards to limit the amount of impervious area generated by parking, or require the use of pervious materials for off-street parking. The City could also amend its Zoning Bylaw to include impervious area directly in the calculation of lot coverage (the current definition of "lot coverage" includes only buildings in the calculation).

- **Subdivision Bylaw –** The City's Subdivision Bylaw establishes servicing requirements for new development. Alongside the OCP and the Zoning Bylaw, the Subdivision Bylaw is among the most important regulatory bylaws adopted by the City, and has the potential to significantly influence stormwater management. The Subdivision Bylaw can apply to both new subdivisions and new developments requiring a building permit, which makes it a suitable tool to regulate re-development of existing lots, which is the type of development White Rock is expected to experience.

  The City's Subdivision Bylaw is currently under review. It is recommended that the revised bylaw include provisions to:

  - Identify areas suitable for infiltration.
  - Establish standards for runoff quality.

- Require developers to install on-site stormwater source control BMPs, use porous pavement, or construct vegetated biofilters where appropriate. Establish standards and criteria for these requirements.

- Establish specific criteria and standards for on-street (and on public parking lots) low impact biofiltration systems (e.g., bioswales).

- Establish specific criteria and standards for enhanced treatment systems.

- Require roof leaders to be disconnected (i.e., to discharge to the ground rather than the storm drain) for single family and duplex development in those areas identified in Figure 7. Disconnecting roof leaders will help ensure more runoff infiltrates into the ground.

- Establish specific tree planting standards as part of highway standards (including requirements for soils to support trees and plant selection – see Section 5.2 for further information)

- Require all new development (i.e., single family, multi-family, commercial, and institutional), to provide, at a minimum, 300 mm of high organic-content amended topsoils in grassed areas. Replenishing the land with a healthy skin of absorbent topsoil is proving to be one of the easiest and most effective methods of managing rainwater, even on small-lot single family sites.

  A depth of 300 mm provides sufficient pore space in the topsoil to fully capture and allow infiltration of the ½ mean annual rainfall depth (30mm in 24 hours) from a typical residential lot with 50% impervious coverage. Currently, most topsoil is removed during development and then the surface is compacted, which results in a hard, impervious surface. To promote infiltration, the required amended topsoils should be placed over a scarified subgrade.

- Establish boulevard/roadway BMP landscape standards.

Including more specific requirements in the Subdivision Bylaw should eliminate the need for ad hoc negotiations with developers for on- or off-lot stormwater infrastructure. The City will have the authority to *require* developers to install drainage works as outlined in its Subdivision Bylaw.

- **Tree Management Bylaw –** The City is currently in the process of developing a Tree Management Bylaw to prohibit the cutting, removal, and damage of protected trees. This bylaw is a positive step towards tree preservation; however, it could be expanded to protect other tree species beyond just the Garry Oak, Arbutus, and Pacific Dogwood in order to protect the tree canopy more generally. As mentioned previously, trees play an important role in stormwater management as they intercept rainwater and decrease runoff volumes, thereby reducing the amount of water that would need to be treated.

- **Erosion and Sediment Control Bylaw –** The City should consider adopting an erosion and sediment control bylaw to further protect Semiahmoo Bay. Such a bylaw would contain guidelines for sediment and erosion control during construction, set specific criteria for excessive solids discharge, and impose fines for offences. It is common practice for municipalities to adopt erosion and sediment control bylaws.

- **Development Permit Area for Landscaping Guidelines, Stormwater Management, and Building Elevation –** The City's OCP already includes landscaping guidelines as part of Development Permit Areas (DPAs) for specific City neighbourhoods. These guidelines could be expanded to all areas of the City through the creation of a City-wide DPA for environmental purposes.

  Additional landscaping guidelines could provide more information on the required depth of absorbent landscaping and on acceptable plant species. Absorbent landscaping would significantly reduce the volume and rate of stormwater runoff – for absorbent landscaping with a depth of 300 mm or more, runoff could be nearly eliminated from undeveloped areas of the lot.[11]

  The DPA could also require developers to meet the stormwater management standards set out in the Subdivision Bylaw and also establish a minimum building elevation (to prevent basement flooding).

- **Drainage Utility User Fees and Development Cost Charges –** Section 6 provides further information on a financing strategy for this ISMP. The City's bylaws related to the drainage utility and Development Cost Charges (DCCs) will need to be reviewed and updated to reflect the new costs identified in this ISMP.

- **Future Neighbourhood Plans –** Any future neighbourhood planning or any future amendments to existing neighbourhood plans should be consistent with and support this ISMP. Land use decisions should be made in light of this ISMP's finding, particularly related to the suitability of on-lot BMPs and infiltration.

[11] Stormwater Planning: A Guidebook for British Columbia, p. 7-15

**Table 10: Recommended Policies and Regulations**

| Recommendation | Benefits | Cost Estimate |
|---|---|---|
| **Establish a DPA for landscaping, compliance with stormwater management standards in Subdivision Bylaw, and minimum building elevation**<br><br>The City's OCP already includes landscape guidelines for its DPAs. These guidelines should be:<br>• Extended to all areas of the City (i.e., a City-wide DPA should be established)<br>• Amended to include more specific landscaping requirements related to stormwater management (e.g., name acceptable species, minimum depth).<br><br>The guidelines should also require compliance with the Subdivision Bylaw and establish minimum building elevations.<br><br>The purpose of the City-wide DPA could be for environmental protection rather than for form and character. Establishing landscaping guidelines through the DP process will give the City and developers the flexibility to tailor solutions to specific circumstances, while still meeting overall objectives. | Landscaping intercepts and absorbs rainfall, thereby reducing stormwater runoff volumes. Reducing runoff volume, in turn, reduces the amount of pollution being washed off hard surfaces and into the City's piped drainage system and then into Semiahmoo Bay. Landscaping also improves the overall aesthetics and livability of the community.<br><br>Minimum building elevations would reduce flood risks. | $15,000 to develop detailed guidelines plus in house costs to amend OCP |
| **Update Zoning Bylaw**<br><br>Amend the Zoning Bylaw to:<br>• Set a maximum for off-street parking stalls or require the use of pervious materials for parking pads<br>• Develop maximum impervious area regulations for all zones | Limiting impervious area reduces stormwater runoff volumes by allowing rainwater to infiltrate naturally. Reducing runoff volume, in turn, reduces the amount of pollution being washed off hard surfaces and into the City's piped drainage system and then into Semiahmoo Bay. | In house costs to amend Zoning Bylaw |

| Recommendation | Benefits | Cost Estimate |
|---|---|---|
| **Update Drainage Utility User Fee Bylaw , No. 1739 (2004)**<br><br>Complete a comprehensive update of the Drainage Utility User Fee Bylaw to reflect new costs identified in this ISMP and the storm sewer condition assessment. See Section 6 for suggestions on incorporating incentives into the fee structure. | Securing stable and sufficient funding for stormwater management initiatives will help the City implement ISMP recommendations. | $50,000 |
| **Update the Development Cost Charges Bylaw, No. 1798 (2006)**<br><br>The DCC program and growth estimates should be reviewed every three to five years to ensure that DCC rates will be sufficient to cover anticipated growth-related infrastructure costs. | Securing stable and sufficient funding for stormwater management initiatives will help the City implement ISMP recommendations. | $60,000 |
| **Update White Rock Subdivision Bylaw, No. 777 (1980)**<br><br>**(currently under review)**<br><br>Update the Subdivision Bylaw to:<br>• Identify areas of the City suitable for infiltration<br>• Incorporate standards for runoff quality<br>• Incorporate specific criteria and standards for low impact on-lot BMPs for commercial, institutional, and multi-family development<br>• Incorporate specific criteria and standards for on-street low impact biofiltration systems (e.g. bioswales)<br>• Incorporate specific criteria and standards for high level treatment systems<br>• Require disconnection of roof leaders for single-family and duplex development in certain areas of the City (see Figure 7) | Stormwater BMPs, topsoil requirements, and disconnecting roof leaders, reduce runoff volume and improve water quality. Reducing runoff volume, in turn, reduces the amount of pollution being washed off hard surfaces and into the City's piped drainage system and then into Semiahmoo Bay. These recommendations will also directly provide runoff quality treatment. | $20,000 |

| Recommendation | Benefits | Cost Estimate |
|---|---|---|
| • Establish specific tree planting standards as part of highway standards (including requirements for soils to support trees and plant selection)<br>• Establish a minimum 300 mm of amended topsoil requirements (minimum 8% and 15% organic content for lawns and planting areas, respectively)<br>• Establish boulevard / roadway BMP landscape standards | | |
| **White Rock Tree Management Bylaw No. 1831 (2008)**<br>**(The City is currently in the process of reviewing this draft bylaw)**<br>Expand the definition of "protected tree," to include other species beyond the Arbutus, the Garry Oak and the Pacific Dogwood, and include provisions to protect the tree canopy in general. | Trees intercept rainwater, thereby reducing runoff volumes and the volume of water that would need to be treated. | In house costs |
| **Ensure future neighbourhood plans are consistent with this ISMP**<br>• Ensure existing and future neighbourhood plans are supportive of stormwater management as per this ISMP.<br>• Identify the application zones for infiltration based BMPs and roof leader disconnections. | All future land use plans should be developed with stormwater management in mind. Neighbourhood design can impact the density and form of development, and therefore, the amount of impervious area and pollution generated. | In house costs |
| **Adopt an Erosion and Sediment Control Bylaw**<br>Adopt an Erosion and Sediment Control Bylaw that controls construction processes and includes specific requirements for controlling the amount of TSS leaving a site. | Reducing the discharge of sediment into the drainage system due to construction activities would help improve the health of Semiahmoo Bay. | $50,000 |

## 5.5 Public Education and Outreach

Public education and outreach initiatives are necessary to foster community-wide support for stormwater management initiatives. Public education is particularly important in White Rock because making significant improvements in stormwater management is likely to require the participation of private property owners.

It is recommended that the City develop and implement a comprehensive public education and outreach program for White Rock. This program could include public recognition of positive stewardship, clean-up days, tree planting programs, disconnecting roof leaders, storm inlet labeling, additional open houses and other opportunities for face-to-face conversation about stormwater issues, brochures, and public service announcements. Public outreach should also include consultation with and education of the development community, including developers, contractors, building material suppliers and design professionals.

**Table 11: Recommended Public Education and Outreach**

| Recommendation | Benefits | Cost Estimate |
|---|---|---|
| **Award for Innovation**<br><br>Initiate a recognition award for developers / builders who use innovative methods to achieve stormwater and environmental objectives. | Provides an incentive for green development and stormwater management practices. | At the City's discretion |
| **Develop and implement a public education program**<br><br>Implement public education programs regarding environmental protection, the City's vision and action plan, and how its residents and development community can contribute. Some key actions may include:<br>• Distribution of educational pamphlets<br>• Expanding the City's website to include further information on stormwater management and environmental issues<br>• Developing school programs<br>• Establishing a communication program to encourage homeowners to disconnect their roof leaders<br>• Implementing communications plans (e.g., with local businesses)<br>• Posting educational information boards at unique demonstration projects, such as Stayte Road | Raising awareness among the public is a key component of implementing an ISMP. Increasing public awareness should result in greater acceptance of City stormwater management initiatives, including increases to drainage fees. Public education could also prompt individuals to become directly involved in environmental stewardship activities. | $30,000 - $50,000 for developing a public education/communications program – additional costs for plan implementation |

# 6 IMPLEMENTATION PLAN

The previous sections recommended a number of initiatives that the City could undertake to improve stormwater management in White Rock. Table 12 on the following page offers implementation considerations around both timing and funding sources.

Based on the priority-setting framework, each recommendation is identified as a "near-term", "mid-term", or "long-term" priority. Near-term initiatives are those that would be undertaken within the next five years; mid-term would be undertaken within the next six to ten years; and long-term initiatives would be assigned for implementation in the years beyond.

The implementation plan also includes direction to the City on suitable funding sources (e.g., DCCs, drainage utility revenues, works and services, etc.) for each recommended initiative.

The actions and costs described herein represent a long term, ultimate state. Realistically, it is expected to take decades to fully achieve it. However, the start point is to identify the long term actions that can be supported to reach the vision. The next step is to develop a practical implementation schedule to achieve it. Consideration for the City's storm sewer capital program and road reconstruction program are both very influential in preparing a comprehensive implementation and financial strategy. It is therefore recommended that consideration for a holistic asset management program be given.

**Table 12: Implementation Schedule**

| Recommendations | Priority | Potential Funding Source |
|---|---|---|
| Municipal Infrastructure | | |
| Implement drainage capital program | Currently underway | Utility-Drainage and DCC |
| Complete condition assessment | Near term | Utility-Drainage |
| Install low impact biofiltration systems (on select streets and public parking lots). Generally long term initiatives linked with paving and road reconstruction programs. | Long term | Utility-Drainage |
| Install enhanced stormwater treatment systems (for 7 catchments). Generally intended to be a shorter term program to address highest risk areas of the City. | Mid term | Utility-Drainage |
| Require low impact BMPs (on-lot). Long term initiative as redevelopment occurs. | Long term | Subdivision Bylaw – Design Criteria – Works and Services Development Builder |
| Develop agreements with land owners south of Marine Drive for access to drainage infrastructure | Near term | Utility-Drainage |
| Environmental Protection and Enhancement | | |
| Develop urban tree planting program | Near term | General Revenue - Parks |
| Complete shoreline restoration (at West Beach boat ramp to pier; and near the rock) | Near term | Utility-Drainage |
| Improve fish access to Coldicutt Creek | Mid term | Utility-Drainage |
| Planning and Analysis | | |
| City to liaise with EPCOR re: mapping aquifer vulnerability | Near term | Water and Drainage Utility |
| Track watershed health indicators | Initiate near term | Utility-Drainage |
| Policy and Regulations | | |
| Establish a Development Permit Area to include: landscaping guidelines; a requirement to meet the stormwater management standards in the Subdivision Bylaw; and a requirement for minimum building elevations. | Near term | General Revenue – Planning Activity |
| Update Zoning Bylaw to limit impervious area | Near term | General Revenue – Planning Activity |

| | | |
|---|---|---|
| Update Drainage Utility User Fee Bylaw to incorporate relevant costs identified in this ISMP and to provide incentives for improved stormwater management practices | Near term | Utility - Drainage |
| Update the Development Cost Charges Bylaw to incorporate relevant costs identified in this ISMP | Near term | Utility-Drainage |
| Additions to the Subdivision Bylaw to establish standards and requirements for stormwater management, particularly for the use of various roadway and on-lot BMPs, as well as landscape standards, | Near term | Utility-Drainage |
| Revise the Tree Management Bylaw to expand the definition of "protected tree" to include a wider range of species | Near term | General Revenue - Parks |
| Develop future neighbourhood plans to be consistent with this ISMP | Near term | General Revenue |
| Adopt an erosion and sediment control bylaw to establish specific requirements for controlling sediment during construction | Near term | Utility-Drainage |
| Public Education and Outreach | | |
| Establish a recognition award for local innovation in stormwater management and environmental protection (potentially for residents, business owners or developers) | Near term | Utility-Drainage |
| Develop and implement a public education program regarding environmental protection, the City's vision and action plan, and how its residents and development community can contribute. | Near term | Utility-Drainage |

City of White Rock

Integrated Stormwater Management Plan

# Appendices

FINAL

1325.0061.01 / April 2010

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# APPENDIX A

## Consultation

This ISMP has been developed in consultation with the public, City Staff, and environmental stakeholders (including senior levels of government). The information collected through consultation with these various groups was fed directly into the development of a vision and related objectives for the watershed.

**Consultation with the Public**

Input from the public was sought through:

- **Open houses**
  An open house was hosted on October 1, 2009 and another will be hosted in 2010. Participants were provided with a one-page backgrounder (see attached) on the ISMP and were invited to review display boards. A short presentation was also given. The first of two public open houses was conducted on October 1, which resulted in a poor turnout of only two visitors, both of which sit on the City's Environmental Committee.

  *pending information on the second Open House following Draft presentation to Council*

- **Questionnaire**
  A questionnaire was posted on the City's website and was also distributed at the City's Sunday Pesticide Drop-Off program. The questionnaire included questions on priorities, values and inquired about any stormwater related issues or problems that may be effecting private property. A total of 7 responses were received.

Public commentary is summarized as follows:

- Respondents support initiatives that aim to improve water quality in Semiahmoo Bay.
- Respondents support the Stayte Road LID project and wish to see more such work undertaken in the City, specifically along Victoria Avenue.
- Respondents identify the beachfront as one of the most highly valued natural features in the City.
- Respondents are concerned about water quality of stormwater runoff, and the water quality of the ocean and streams in White Rock.
- Respondents identify climate change and past floods as the most prominent reason for their concern about flooding.

The overall sentiment is that residents are very supportive of future environmental initiatives in the City of White Rock. Recent initiatives, such as the development of the Tree Protection Bylaw and the Cosmetic Pesticide Use Bylaw are also well supported by the public.

**Consultation with Staff**

The Project Team met with City Staff at various points throughout Plan development to obtain a thorough understanding of the issues and to assess the suitability of various options for managing stormwater. Specific discussions were held with engineering, operations, environment, planning, and finance. These discussions helped tailor the Plan to White Rock's specific circumstances. The results of these discussions are reflected throughout this ISMP.

**Consultation with Environmental Stakeholders**

The following environmental stakeholders were consulted as part of ISMP development:

- Federal Department of Fisheries and Oceans (DFO)
- Ministry of Environment (MoE)
- Boundary Bay Ambient Monitoring Program (BBAMP)
- City of White Rock Environment Committee
- EPCOR
- City of Surrey

The Project Team also attended the City's Environment Committee meeting and made a short presentation. These organizations were contacted to discuss the ISMP process and to obtain input on objectives for stormwater management.

Krista Payette (MOE and member of BBAMP) emphasized the importance of improving stormwater quality from the marine outfalls and to the Little Campbell River (Habgood St. outfalls) and protection of the identified water uses for Semiahmoo Bay (aquatic life, swimming). Based on previous conversations with agency staff for ISMPs and water quality issues, it is likely that they will support improvements to water quality for the receiving environment of Semiahmoo Bay as a primary objective.

877 Keil Street
White Rock, B.C. V4B 4V6
Telephone: (604) 541-2181
Fax: (604) 541-2190

# The City of White Rock

## Integrated Stormwater Management Plan Resident Survey

**Date:** ______________________________

**Name:** ______________________________

**Address:** ______________________________

**Phone:** ______________________________

**E-mail:** ______________________________

1. **How long have you been a resident of White Rock?**

2. **Are you aware of any particular water, drainage or erosion issues? If so, please explain.**

3. **What elements of White Rock's natural environment (e.g., streams, beaches, wildlife) would you say you value most? (please be specific)**

4. **Where would you like to see the City concentrate its efforts:**

   a. Improving drainage infrastructure ☐
   b. Improving flood protection ☐
   c. Improving overall environmental conditions ☐
   d. Improving trees and landscaping ☐
   e. Reducing the level of pollution on the beach ☐
   f. Improving water quality of Semiahmoo Bay ☐
   g. Other? ______________________________

5. **Are you often concerned about your property flooding? Or flooding throughout the City? What causes you to be concerned? (climate change, past floods, clogged drains etc).**

As you have likely noticed, Stayte Road has been reconstructed from Marine Drive to North Bluff Road. The road has been designed to minimize the impact of stormwater runoff by allowing rainwater to mimic the natural hydrological cycle.

**Before**

**After**

6. **What do you find most appealing about Stayte Road?**

7. **Given the increased benefits of Stayte Road, are you supportive of using this same approach in other areas of the City?**

8. **Is there anything else you would like to add?**

Thank you for your participation in this process!
Please drop-off, mail or fax your completed survey **by October 7th 2009** to the City of White Rock Operations Building or to City Hall. You can also e-mail your completed survey to: **mfuhrmann@city.whiterock.bc.ca**

**White Rock City Hall**
15322 Buena Vista Ave
White Rock, B.C.
V4B 1Y6

**Operations Building**
877 Keil Street
White Rock, B.C.
V4B 4V6
**Fax (604) 541-2190**

# An Integrated Stormwater Management Plan for White Rock

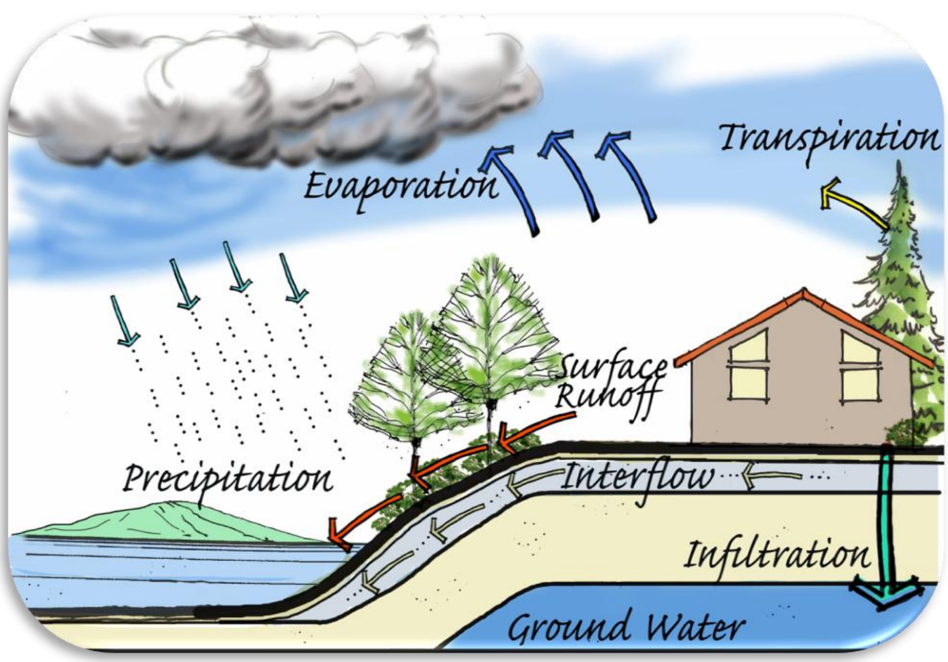
**The City of White Rock**
877 Keil Street
White Rock, B.C. V4B 4V6
Phone: (604) 541-2181
Fax: (604) 541-2190

The City of White Rock has recently initiated the development of an Integrated Stormwater Management Plan (ISMP). An ISMP is a plan that brings together **engineering**, **planning** and **environmental** perspectives to create a long-term strategy for effectively managing stormwater. The ISMP will identify specific strategies to protect and restore the natural watershed; to reduce the threat of flooding and erosion; and to guide sustainable community development. This ISMP is one of several important initiatives the City is undertaking to improve the community's sustainability.

## What Happens to Rainwater?

Water moves through a continuous, closed cycle, above and below the surface of the Earth. We must responsibly manage the water we use today, as it will be the same resource we draw from in the future. Under natural conditions (i.e., no development), soil and plants absorb rainwater, filter out impurities and replenish groundwater or feed streams. During development, buildings, roads and other "impervious surfaces" replace soils and vegetation. This causes the volume and rate of runoff, as well as the level of contaminants in the runoff, to increase. When it rains, runoff quickly flows over impervious surfaces and enters the City's storm drains, most of which empty into Semiahmoo Bay.

## The Water Cycle




## How Will the City Use the ISMP?

- To implement land use regulations and policies
- To encourage sustainable development practices
- To improve water quality and environmental conditions
- To invest in drainage infrastructure
- To reduce the risks of flooding and erosion
- To establish funding strategies

# The ISMP Process

## Stage 1: What Do We Have?

Stage 1 is now underway. Urban Systems is busy gathering data on rainfall, water quality, infrastructure, etc., to complete the analysis.

## Stage 2: What Do We Want?

Stage 2 is about identifying a vision for the watershed and assessing strategies to realize that vision. As part of the consultation process, the City is calling on White Rock residents to help identify stormwater related objectives for their community.

## Stage 3: How Do We Put It Into Action?

Once clear direction has been set, the next stage will be to develop an implementation plan. The implementation plan will include action items related to: drainage infrastructure, environmental enhancement, policy and regulations, education, land use, and monitoring.

## Stage 4: How Do We Stay On Target?

Implementing an ISMP is an ongoing process. To make sure the City stays on track, key performance targets, a monitoring program, an assessment plan, and an adaptive management process will be developed in Stage 4.

If you have any questions regarding this process please contact:

Marlene Fuhrmann
Environmental Coordinator
Corporation of the City of White Rock
877 Keil Street, White Rock B.C. V4B 4V6
Phone (604) 541-2192 Fax (604) 541-2190

# APPENDIX B

## Environmental

# Memo

**Stantec**
4370 Dominion Street, 5th Floor
Burnaby, BC V5G 4L7
Tel: (604) 436-3014
Fax: (604) 436-3752

| | | | |
|---|---|---|---|
| **To:** | Mr. Glen Shkurhan<br>Urban Systems | **From:** | Karen Munro<br>Stantec |
| Project: | 1055860 | Date: | December 7, 2009,<br>updated April 10, 2010 |

**Reference: White Rock ISMP – Discussion Paper #2 – Final Report**

As requested, here is updated information for Discussion Paper #2. This document includes comments from regulatory agencies on objectives for the White Rock ISMP, an update on rare species and marine habitat (to be integrated with information contained in Discussion Paper #1), information on the indicators of watershed health (impervious area, tree canopy cover, fecal coliforms in Semiahmoo Bay / beach closures), and a summary of the hydrogeology report.

### Objectives for White Rock ISMP

The White Rock ISMP project was introduced to staff from relevant regulatory agencies and their input was sought on objectives for the White Rock ISMP. Krista Payette (MOE, member of Boundary Bay Aquatic Monitoring Program [BBAMP]), Al Jonsson and Brian Naito (DFO) and Marlene Furhman (City of White Rock) provided the following comments:

- Improving stormwater quality from marine outfalls and protecting water quality in Semiahmoo Bay for identified water uses (aquatic life, swimming) is a high priority
- Safe conveyance of stormwater (preventing flooding) is important
- While not within the scope of this ISMP, White Rock also discharges stormwater to Semiahmoo Bay via the Habgood Street outfalls into Little Campbell River, so improvements to quality of this discharge will also be important in improving water quality of Semiahmoo Bay

### Environmental Conditions and Habitat – Rare Species

Based on a review of the current BC Conservation Data Centre rare element tracking database, no rare species have been documented within the city limits of White Rock; however, four species of wildlife and three of plants have been reported within 5 km of the City. These include Green Heron (*Butorides virescens;* Blue-listed), Pacific water shrew (*Sorex bendirii;* Red-listed and Endangered), Oregon forestsnail (*Allogona townsendiana;* Red-listed and Endangered), Trowbridge's shrew (*Sorex trowbridgii;* Blue-listed), field dodder (*Cuscuta campestris;* Blue-listed), Vancouver Island beggarticks (*Bidens amplissima;* Blue-listed and Special Concern), and needle-leaved navarretia (*Navarretia intertexta;* Red-listed) (BC CDC 2009).

### Environmental Conditions and Habitat – Marine Environment

The extensive sand, mudflat and eelgrass areas in Semiahmoo Bay provide highly valued habitat for marine vegetation, intertidal productivity, salmonids, other marine species, and birds. Semiahmoo Bay is part of the Boundary Bay Wildlife Management Area and is especially recognized as habitat for migratory and resident birds. Boundary Bay has been designated an 'Important Bird Area' (IBA) by Birdlife International and Semiahmoo Bay was designated as a site of hemispheric importance in 2005 as part of the Western Hemispheric Shorebird Reserve Network.

More than 333 species of birds have been identified in Semiahmoo Bay, including shorebirds, waterfowl, raptors and songbirds, some of which are rare or endangered. Semiahmoo Bay hosts over 100,000 overwintering waterfowl, is a major stopover site for shorebirds on the Pacific Flyway and is home to the largest winter population of raptors in Canada. Birds come to Semiahmoo Bay because its rich ecosystem provides ample food resources, shelter and safety from predators. Eelgrass beds, mudflats and salt marshes provide habitat to myriad algae, marine invertebrates and fish that feed many species of birds (Jacques Whitford AXYS 2008a).

Waters from the major tributary streams and the stormwater outfalls deliver suspended solids, metals, nutrients, organic matter and fecal coliforms to Semiahmoo Bay (Environment Canada 1988). As a result of elevated fecal coliform contamination, the shellfish harvest has been closed since 1962 (Shared Waters Alliance 2006), however, Boundary Bay still sustains other fisheries.

With over four kilometres of waterfront, White Rock is famous for its beautiful sandy beaches with warm swimming water, hosting thousands of visitors during the summer and providing a substantial economic base of the community.

### Watershed Health Indicators

An ISMP typically includes indicators of watershed health, to assess current conditions and provide a baseline for future monitoring (Kerr Wood Leidal 2006). White Rock differs from many jurisdictions in Metro Vancouver in the lack of fishbearing streams (only three remnant streams, none of which are fish bearing) and direct discharge of stormwater to the marine environment. The watershed health indicators described in the Metro Vancouver ISMP template are condition of the streamside (riparian) vegetation and amount of impervious cover. In streams, effectiveness of the ISMP strategies is monitored with surveys of benthic invertebrates and water quality. Given the lack of streams, it is important to identify indicators of watershed health and ways of monitoring effectiveness of the ISMP strategies that are relevant to White Rock.

Three indicators have been developed, all of which are linked to objectives of the ISMP and can be monitored over time. These are listed in Table 1, along with current status of the indicator, and described in detail below. Data from other monitoring programs can also be tracked as part of an assessment of watershed health and performance of the ISMP. Some of these include:

- water quality of the Little Campbell River at the mouth (assessed periodically through BBAMP)

- metals and polycyclic aromatic hydrocarbon levels in sediment near the outfalls to Semiahmoo Bay (assessed through partnership with BBAMP)
- change in health or extent of eelgrass beds in Semiahmoo Bay (using stewardship group monitoring as it is available)
- Drayton Harbour shellfish harvesting conditions (given that a previous study of circulation patterns indicated that bacterial levels in Drayton Harbour may be influenced by inputs from the Little Cambell River and stormwater outfalls into Semiahmoo Bay).

**Table 1: Watershed Health Indicators for White Rock ISMP**

| Indicator | Type of Indicator | Baseline Status | Potential Target | Ability to Update Status |
|---|---|---|---|---|
| Impervious cover | Land development, ability of land to infiltrate rainwater | 56% TIA<br>43% EIA | No change in EIA | Can be assessed annually using zoning information |
| Tree canopy cover | Amount of urban tree cover, ability of trees to intercept rainwater | 15% (2002 images) | To be discussed with City | Metro Vancouver will update in 2010 using 2009 images |
| Fecal coliform levels in Semiahmoo Bay | Indicator of water quality, influenced by stormwater discharges and other sources | No beach closures since at least 1993 | No beach closures | Assess and report annually |

**Watershed Health Indicator #1 - Impervious Cover**

During development, paved surfaces and buildings replace the natural soils of a watershed. These impervious surfaces restrict the amount of rain that can be naturally infiltrated and they tend to direct runoff into the stormwater infrastructure. Total impervious area (TIA) provides a measure of how much land is covered by impermeable structures and effective impervious area (EIA) provides a measure of how much land is actually connected to the stormwater system. Alternatives such as green roofs, disconnected roof leaders (downspouts), rain gardens, bioswales and permeable pavement are commonly used strategies to reduce the amount of impervious area by directing the rain into the soil rather than the stormwater system.

The Metro Vancouver ISMP template uses TIA, or where available, EIA as an indicator of watershed health, as they can be measured over time, related to ISMP objectives, and addressed in municipal planning processes. The relevance to White Rock, where there are no fish-bearing streams, is that strategies to increase infiltration on private and public property will reduce the overall volume of stormwater, which in turn should improve water quality.

The 56% TIA estimate for White Rock in 2009 was calculated by assigning commonly recognized %TIA values for commercial, institutional and residential land uses. This value indicates approximately one-half of land in the City has some capacity to infiltrate stormwater. Metro Vancouver published a similar TIA estimate based on 1996 data: 51% TIA for the larger White Rock catchment (southwest Surrey and White Rock); they predicted an increase to 61% by 2036 with full development of the area (GVRD 1999).

However, TIA overestimates EIA as it does not recognize the benefits of disconnecting hard surfaces from the stormwater infrastructure and inefficiencies in the existing inlet system. Although it is not possible to accurately determine EIA using currently available records, the TIA calculation can be adjusted, removing obvious structures not connected to the storm system (e.g., some driveways and parking areas), providing a rough estimate of 43% EIA. Additional analysis may be required to further refine this estimate of %EIA.

Comparisons can be made with values estimated for various Metro Vancouver watersheds (GVRD 1999), although caution is needed, as land uses vary from one watershed to another. On a geographic basis, the comparison is with other areas that drain to Boundary Bay: the Little Campbell River watershed (including upstream agricultural areas) had 9% TIA, the Serpentine River watershed (several tributaries in south Surrey) had 25% TIA and the Nicomekl River watershed (several tributaries throughout Surrey) had 13% TIA in 1996. For more built up communities, TIA ranged up to 57% (e.g., 41% for Hyland Creek in central Surrey, 45% for Kitsalino – Kerrisdale in Vancouver, 57% for lower Lonsdale in North Vancouver).

The value of the impervious cover indicator is that it provides a target for future City growth, and a means of promoting increase in infiltration of stormwater on site during development. Although %TIA will continue to increase during urban development, the ISMP strategies focus on ways to avoid additional inputs to the stormwater system, by maintaining EIA at current levels or reducing it. The recommended target for White Rock is no increase in %EIA.

### Watershed Health Indicator #2 – Tree Canopy Cover

An indicator of tree canopy is relevant to stormwater management because trees play an important role in taking up stormwater, both through the roots and through interception in the canopy itself, a role that is increasingly being recognized economically as well as environmentally. Estimates of returns on investment in terms of funds that would otherwise be spent on stormwater infrastructure and management range from $1.30 to $3.09 per dollar spent on tree planting and maintenance (Asadian and Weiler 2009). Trees also provide other benefits, such as helping to purify the air and water. Tree canopy cover, which measures current levels of land development, has been used as an indicator of watershed health in Metro Vancouver (AXYS 2006, Caslys Consulting Ltd. 2006, Jacques Whitford AXYS 2008b). Measuring tree canopy over time will track how well the City balances urban development with ecosystem health. Maintenance of urban trees was also identified as a high priority in the Environmental Strategic Plan and will be supported in the proposed Tree Protection Bylaw, so it makes sense to find a way to track effectiveness of these policies over time in maintaining the canopy.

Tree canopy cover for Metro Vancouver and individual jurisdictions was calculated in 2005 using images from 2002 (the 2002 Landsat 7 data), based on the CITYgreen model (AXYS 2006). This information can be used to provide a baseline for the tree canopy indicator in White Rock. Values reported by AXYS (2006) included water (ocean), so values are recalculated here for land areas only.

Figure 1 shows land coverage for open space (including cropland), shrubs, trees and urban areas (all urban categories combined): 71% (362 ha) was urban, 15% (78 ha) was treed, 8% (42 ha) was open space and 6% (29 ha) was covered by shrub in 2002. Tree canopy may be higher than 15% because of the resolution used to analyze the images, although the calculation did recognize contributions of trees and shrubs on urban properties). However, a relatively low percent tree cover might be expected for the built up White Rock community. Shrubs and open space also provide ecosystem benefits, including infiltration of rainwater, but to a lesser extent than the tree canopy. The model does not assess the influence of other best management practices for stormwater control (e.g. green roofs, gardens and infiltration facilities).

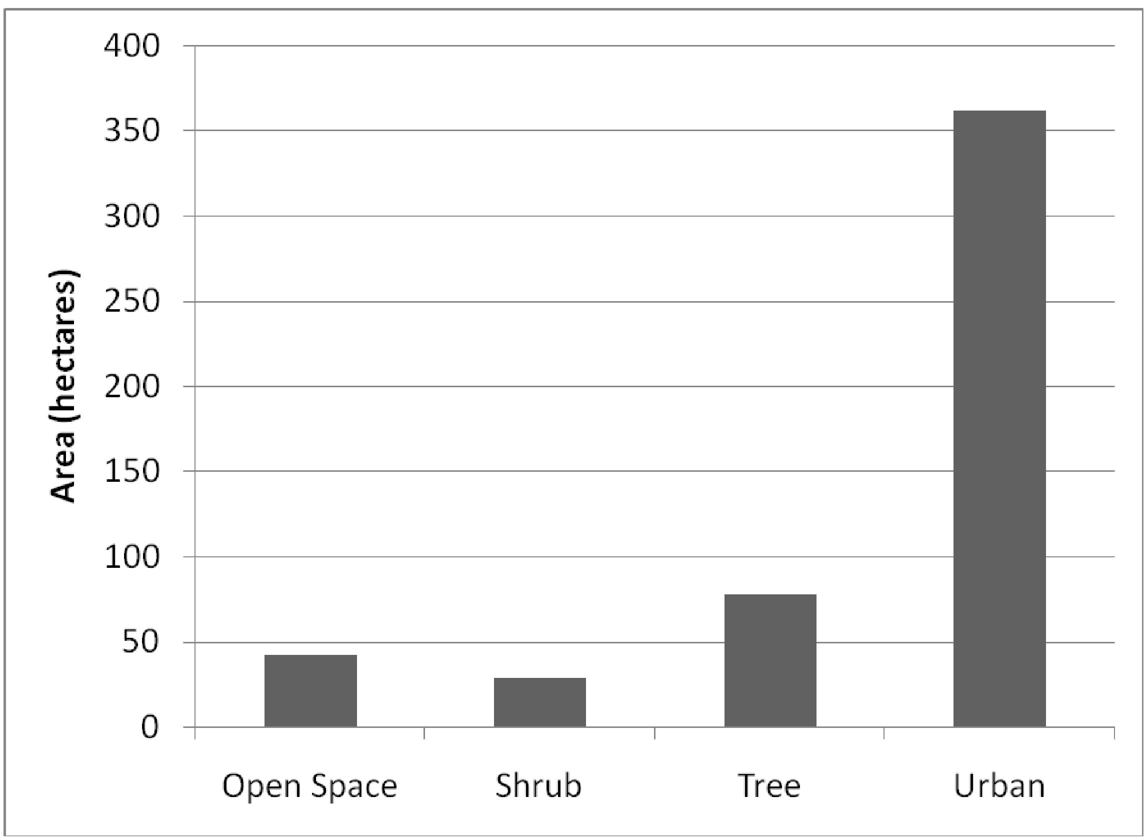



**Figure 1: Land Cover for White Rock in 2002**

The “City Green” model used to assess benefits of tree canopy established targets for urban areas in the Pacific Northwest ranging from 15% for central business districts, to 25% for high density residential areas to 50% for low density residential areas, with an overall target of 40% for all land use types (AXYS 2006). When applied specifically to six watersheds in Metro Vancouver, only one (an intact forested watershed) met these targets; tree cover ranged from 4% in an agricultural area (Chillukthan Slough watershed in Delta) to 34% in a mixed use watershed (Yorkson Creek in Township of Langley), with intermediate values for other mixed-use watersheds (26% in Hyland Creek watershed, Surrey, 20% in Maple Ridge Town Center and 12% in Still Creek watershed, Vancouver and Burnaby). Hence, results for White Rock are typical of some Metro Vancouver jurisdictions and, like these areas, are below preferred targets for a healthy watershed.

A target for tree canopy cover in White Rock will need to be developed in consultation with the City and in the context of other municipalities with similar landscape functions. Metro Vancouver has plans to update the tree canopy cover study in 2010, based on 2009 land cover images. This study will provide a useful tool for the City of White Rock to track the changes to canopy cover over the last few years and assess effectiveness of the Tree Protection Bylaw and stormwater management strategies in the future.

Many studies have shown the economic as well as environmental benefits of maintaining tree canopy cover, which include a reduction in the cost and amount of stormwater infrastructure, pollution removal, carbon storage and sequestration, and improvement in air quality (AXYS 2006). Rainwater interception is about twice as high for coniferous trees compared to deciduous trees (Llorens and Domingo 2007 as cited by Asadian and Weiler 2009). A study conducted in North Vancouver measured the amount of rain intercepted by Douglas fir and western red cedar alone and in stands; over several rainfall events, interception rates ranged from 5% to 98%, with an average of 49% for Douglas fir and 61% for red cedar (Asadian and Weiler 2009).

### Watershed Health Indicator #3 – Fecal Coliforms

Water quality in Semiahmoo Bay reflects activities on land and is often a concern in areas that receive stormwater inputs. Physical parameters (temperature, conductivity, pH, dissolved oxygen, turbidity), bacteria, nutrients and metals can provide evidence of degraded water quality due to human influences. Stormwater from the marine outfalls is greatly diluted when it enters Semiahmoo Bay and is dispersed by tidal action and currents. This high dilution can make it difficult to measure changes in many of the parameters typically used to assess effects of stormwater on receiving environment water quality. However, fecal coliform bacteria is one type of contaminant that has been tracked for many years, due to its relevance to human health, both for swimmers and for consumption of shellfish.

There are many potential sources of fecal coliforms, some of which are challenging to identify and manage. Stormwater can convey fecal coliforms from pet wastes, wildlife or cross-connections with the sanitary sewer system, and is discharged through the marine outfalls and freshwater outfalls into the Little Campbell River. In addition, some of White Rock’s infrastructure conveys runoff from Surrey, upslope of 16 Ave (outside the scope of this ISMP and jurisdiction of the City). In White Rock, cross-connections with individual residences have been studied and repairs made where discovered (David Pollock, Director of Operations, pers. comm.). Indirect interactions between the sanitary and storm sewer systems are also possible, particularly along Marine Drive at sea level, where the two systems are in close proximity. When the soil is saturated during prolonged rain or with high tide levels, there is potential for infiltration and exfiltration of materials from one sewer system to the other through leaks in the aging infrastructure and transmission through the sandy, highly permeable soils. Stantec and Urban Systems are currently conducting a study to assess coliform levels upslope and downslope of Marine Drive in three stormwater systems to assess the likelihood of this pathway for coliforms. Data collected to date during three rain events are not conclusive, perhaps because the rain and soil conditions have not been ideal since April. Study results will be useful in setting priorities for stormwater management and improving water quality in relation to other infrastructure needs. For example, if the sanitary system is identified as an important source of coliforms in stormwater, improvements may be most effective for the sanitary system, and any Best Management Practices (BMPs) and other actions likely to be recommended in the ISMP may not be successful in reducing coliform levels.

A fecal coliform indicator is highly relevant to White Rock because of implications for recreational use, primarily swimming. Metro Vancouver monitors all swimming beaches in its jurisdiction during the swimming season (generally April through September). Beach closures are posted if levels of fecal coliforms exceed the guideline. As discussed below, there have been no beach closures since at least 1993 (earliest data reviewed for this report).

Semiahmoo Bay once produced 50% of the commercial clam harvest in the province and provided an important resource for the Semiahmoo First Nations. However, shellfish harvesting has been banned in the bay since 1972 because of elevated levels of fecal coliform bacteria. Wastewater treatment standards have improved greatly 1972, and sanitary waste has been directed to the Annacis Island wastewater treatment plant since 1977. However, the closure remains in place because coliform levels remain above standards for shellfish harvesting.

Coliforms live in soil, water and intestinal tracts of cold- and warm-blooded animals. Fecal coliforms, including *Escherichia coli*, are specific to mammals, including humans. The presence of *E. coli* and other fecal coliforms indicates contamination with fecal material. One common source is stormwater (which can convey bacteria contained in waste from pets and wildlife), although there are also other sources such as human wastes (septic fields, sanitary sewer cross-connections and maintenance issues) and tributaries such as the Little Campbell River.

Several studies have been conducted since 1999 to better understand the sources and pathways of coliforms into Semiahmoo Bay. These include studies of coliforms in storm outfalls conducted by Shared Water Alliance (Cheung 2003), circulation in Semiahmoo Bay (Hay and Co. 2003) the Little Campbell River (Juteau 2008; Zevit et al. 2008) and sanitary system interactions (as discussed above). Chueng (2003) reported that all the stormwater outfalls into Semiahmoo Bay had elevated coliform levels (defined as >1000 fecal coliforms/100 mL) at least some of the time. The Little Campbell River has been identified as the largest source of fecal coliform bacteria in the Bay, with the Serpentine River, Dakota Creek and Habgood Street outfall also being significant sources.

Metro Vancouver monitors four to five locations along the beach regularly, generally from April through September. Levels of *E. coli* are compared with BC water quality guidelines for primary contact recreation (Ministry of Environment 2006), which is 77 organisms per 100 mL. If mean levels (geometric mean of five triplicate measurements on five dates) exceed this guideline, a notice of beach closure is issued and *E. coli* sampling occurs more frequently. The closure is lifted when mean numbers again meet the guideline. Data from 1993 to 2009 indicate occasional exceedance of the recreational use guideline for individual dates, reflecting the high variability in bacterial counts and sporadic occurrence at elevated levels; however, there have been no beach closures since at least 1993.

**Constraints and Opportunities**

Restoration options have been developed based on an understanding of environmental constraints and opportunities applicable to the City of White Rock. Given the lack of fish bearing streams, the highest priority is to improve stormwater quality and reduce quantity by removing contaminants wherever feasible and increasing natural capacity of the land to absorb rain before it reaches the streets (source reduction). In addition to engineered stormwater treatment options, increasing the amount of tree cover will provide benefits to stormwater management, wildlife and general livability of the area. Some options for habitat restoration in the freshwater and marine environment are also presented below, although these would be considered a lower priority, given that the greatest benefit would come from reducing pollutant levels in stormwater runoff.

Recommended actions for the City of White Rock to improve water quality and reduce stormwater volume include:

- In consultation with the City Parks Manager, develop a comprehensive Urban Tree Planting program the addresses both private and public lands, with demonstrated linkage to the Tree Preservation Bylaw.
- In consultation with the City Parks Manager, develop landscape standards for both the Urban Tree Planting program and landscape-based BMPs, focusing on native, low maintenance species.
- Initiate a recognition award for developers who use innovative methods to achieve stormwater and environmental objectives.
- Continue to undertake pilot projects (alternate road design, rain gardens, porous pavements, recharge galleries) on City property or as part of new development (in partnership with development community).
- Encourage or require (through zoning bylaw amendment to define lot coverage) use of porous pavements. Further dialogue is required with City staff with respect to acceptable materials types and applications.

- Develop public education programs with local residents to provide them with a greater sense of connection to the environment and the City's vision for the community.

Suggested education and awareness actions include:

- Enhancing the City web site
- Installing educational signs at sites that incorporate BMPs
- Preparing a brochure that describes water conservation techniques
- Encouraging retention of as much native vegetation as possible on private property, removal of exotic and invasive species and use of amended soils in landscaped areas (with additional organics and topsoil to encourage retention of water)
- Providing a list of local composting facilities and encouraging homeowners to obtain amended soils and organic materials from these facilities (or composting at home)
- Providing a list of recommended native plant species to plant on private property
- Encouraging establishment of riparian fencing on private property and use of native vegetation for riparian habitat
- Encouraging clean up of garbage and debris from the roadside ditches, curbs and gutters, and appropriate pick up and disposal of animal (dog) feces (the City could also provide bags and disposal containers at all park entrances)
- Coordinating with publicity effort for the Cosmetic Pesticide Bylaw, highlighting the adverse effects of herbicides and pesticides on water quality and encouraging alternatives
- Encouraging residents to decrease impervious surfaces (disconnect roof leaders, use pervious paving, etc.)

Opportunities for restoration of marine and freshwater habitat have also been identified, which could be pursued if at some point, agencies require specific works to improve fish habitat.

Current concerns about ocean survival of salmonids have led to interest in the role of forage fish such as surf smelt and sand lance, which are important prey for many fish and bird species. Friends of Semiahmoo Bay commissioned a study into forage fish habitat in Boundary Bay (de Graaf 2007) and identified opportunities to protect and enhance habitat for these species. Shoreline development (riprap, stormwater outfalls, removal of overhanging vegetation) has disrupted the natural replenishing of spawning substrates (coarse sand and fine gravel) and altered historic transport processes that move the substrates along the beach. The West Beach boat ramp to the White Rock pier and the area around the "Rock" are two locations where recommendations were made to replace gravels and coarse sand for forage fish spawning and plant native vegetation to shade the upper intertidal area and improve juvenile survival (de Graaf 2007). A pilot project could be developed to place spawning substrates, plant shoreline vegetation, assess use of the habitat by forage fish, and determine stability of the substrates and frequency of substrate replacement required. This might best be done in partnership with Friends of Semiahmoo Bay with input from DFO, and would likely involve volunteer monitoring of the pilot site. If successful, additional restoration sites could be added.

Improving access from Semiahmoo Bay to Coldicutt Creek would enable salmon to enter and colonize the stream. Prior to undertaking such a project, water quality, flows and the benthic invertebrate community (food supply) would need to be assessed to confirm that conditions are suitable for salmonids, Some of this pre-project assessment could be done by interested volunteers (e.g., through the Streamkeepers stewardship approach). Physical restoration would include improving access at the beach (the creek currently empties through a culvert under the rail bed and splashes onto rocks at the beach, with access to the culvert only during high tide) and improving habitat upstream of the culvert (complexing with large boulders and woody debris, removal of garbage, removal of invasive Himalayan blackberry and replacement with native vegetation). Some of this restoration work could be conducted by interested volunteers, although instream work would require technical input from professionals for design, approvals and construction.

### Groundwater Conditions and Constraints for Infiltration

The hydrogeology assessment of White Rock (Stantec 2009), provided as an appendix for the ISMP, describes soil types, hydraulic conductivity, groundwater occurrence, groundwater recharge and characteristics of the Sunnyside Uplands Aquifer underlying the City, and discusses considerations for infiltration of stormwater as a management strategy. Protection of groundwater quality is a high priority, as the aquifer is the drinking water source for White Rock.

Surficial soils, where present within the City limits, have a good capacity for infiltration of rain. The distribution of sandy surficial soils, however, was not well described in available documents, so it is not clear where infiltration strategies could be used. Well logs for the production wells (PW#1 to PW#6) suggest a wide variability in infiltration potential near surface soils.

In the central area of the City, well logs provided by EPCOR provide clear evidence of a thick clay layer (in the Vashon Drift Formation) separating the deep aquifer from upper groundwater, which protects the deep groundwater from surface influences. This thick clay layer, however, does not appear to overlie the entire aquifer. Production layer #5 is located to the south, lower in elevation and stratigraphically below this clay layer. Also, the clay layer was not identified in the log for production well #6 in eastern White Rock. Further, because the clay layer could not be readily identified in all the wells, the lateral extent of the clay layer is not well established. This suggests there may be a risk that surface water (e.g., road runoff) could infiltrate in certain areas (low-lying areas below 50 masl, or in recharge zones devoid of intervening clay barriers) and introduce contaminants to White Rock’s drinking water source. This effect is likely somewhat alleviated by the thickness of overlying sediments and the overall nature of the Vashon Drift Formation, which is typically characterized by compact till and finer-grained deposits that transmit water relatively slower than the overlying and underlying units.

It is clear that further work is needed to identify where there are risks of stormwater contaminants entering the aquifer currently or in the future. Site-specific BMPs for infiltration could be developed for the ISMP with additional information that considers infiltration potential, percolation rates and times, and potential transport pathways. For example, percolation travel time to the aquifer will be less for the low-lying areas than for eastern White Rock, so these areas are at higher risk. Thus, even without a thick clay layer, factors such as thickness of overlying soil, travel time to the aquifer, and adsorption of contaminants such as metals and hydrocarbons onto soil particles can help protect water quality of the aquifer. It would be helpful to characterize these conditions across the watershed prior to finalizing site-specific requirements and establishing relative zones of risk. At this time, they can only be broadly addressed in the ISMP. EPCOR has commissioned a comprehensive report on the City's drinking water wells, focusing mainly on water supply. The report was not provided in time for consideration in the ISMP, so we cannot identify the extent to which it addresses protection of drinking water quality (e.g., from risks of stormwater infiltration, wellhead protection).

Caution is used in recommending strategies for rainwater infiltration, based on findings of the hydrogeology study and lack of adequate knowledge of the subsurface, including aquifer confinement. For example, strategies could focus on increasing infiltration of rainwater from areas uncontaminated by road runoff (e.g., on vegetated areas, from roofs). This would include improving soil quality and planting vegetation, especially coniferous trees. Strategies for infiltrating road runoff could focus on using available treatment technologies to improve water quality. For example, infiltration swales could be designed with soils and biofilters that are appropriate for the expected contaminant loads, while regular monitoring and maintenance schedules form an integral component for these systems.

Sincerely,

**Stantec Consulting Ltd.**

***Original signed by:***

Shelly Norum, B.Sc., R.P.Bio.
Environmental Scientist
Environmental Management Group
shelley.norum@stantec.com

***Original signed by:***

Karen Munro, M.Sc., R.P.Bio.
Aquatic Toxicology Team Leader

karen.munro@stantec.com

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# APPENDIX C

## Hydrogeological

**Stantec**
4370 Dominion Street, 5th Floor
Burnaby, BC  V5G 4L7
Tel: (604) 436-3014
Fax: (604) 436-3752

**VIA EMAIL**

December 7, 2009, updated April 12, 2010

Project No: 1055860

**Urban Systems Ltd.**
2353-13353 Commerce Parkway
Richmond BC  V6V 3A1

**Attention:  Glen Shkurhan, P.Eng.**

Dear Mr. Shkurkan:

**Reference:** **White Rock Integrated Stormwater Management Plan – Hydrogeology**

# 1 INTRODUCTION

Jacques Whitford Stantec AXYS Limited (Stantec) is pleased to provide The City of White Rock (White Rock) with the following hydrogeological component of the Integrated Stormwater Management Plan (ISMP) for White Rock. The ISMP is based on requirements outlined in the GVRD Integrated Stormwater Management Plan (ISMP) template, requirements of Request for Proposal (RFP) 2009-07 and Stantec's proposal dated August 21, 2009. The location of White Rock is shown on **Drawing No. 1** in **Appendix A**.

Urbanization (e.g., commercial and residential development with associated culverted streams, paved roads, and high rooftop density) results in the removal of trees and native vegetation, an increase in impermeable area and a corresponding reduction in, or removal of, porous topsoil materials. These activities tend to reduce natural infiltration of water from rainfall and snowmelt in the ground, reduce subsurface storage volumes for infiltrated groundwater, reduce overland flow times for runoff and increase flood potential. In essence, the combined effects of urbanization result in changes to both hydrologic function and groundwater regime.

Promoting infiltration by constructing individual lot or larger scale infiltration galleries that collect road, parking lot and roof runoff is a commonly used stormwater management strategy to offset these effects of urbanization. For White Rock, it is important to consider both quantity and quality of the recharge to groundwater, given that the drinking water source is a sand and gravel aquifer underlying the city. Protection of drinking water quality, therefore, is a high priority, and any infiltration strategies should avoid introduction of contaminants that may be present in urban runoff.

# 2 SCOPE AND OBJECTIVE

The primary goals of this hydrogeological assessment (as input into the ISMP) are to identify the geology, soil types and distribution of water-bearing units underlying the White Rock area, and describe the hydrogeologic regime of the area. The information can then be used to assess implications of any proposed recommendations on storm water infiltration, the storage capacity and groundwater movement.

To meet these goals, Stantec reviewed geologic and topographic maps for the area, production well logs provided by EPCOR and on-line water well and aquifer data available from the Ministry of Environment's British Columbia Water Resources Atlas (BCWRA). We understand that a comprehensive report on the City's drinking water wells is currently being prepared for EPCOR. If that report is available prior to completion of the ISMP report, applicable information will be updated.

# 3 PHYSICAL ENVIRONMENT

## 3.1 Climate Data

The climate of the White Rock area is controlled by proximity to the ocean and is generally typical of the Pacific Northwest. The ocean has a moderating effect on the year-round temperature in the Lower Fraser Valley. Mean temperatures range from 3.3°C in January to 17.5°C in July (recorded at the Vancouver Airport). Mean annual rainfall ranges from 1200 – 1500 mm for the area [Environment Canada 2009]. Approximately 75% of the total annual precipitation in the Lower Fraser Valley is received in the late fall and winter as Pacific weather systems move onto the coast from the southwest. The area is open to sourthwesterly flows of warm, moist air, which are responsible for the heaviest rainfalls for durations greater than one or two hours.

This relatively high seasonal distribution of precipitation can contribute to seasonally high groundwater levels and to drainage challenges in specific areas of low infiltration capacity. Intense convective rainstorms also occasionally occur during the summer. These events are often spatially confined and of less duration than the winter storms. Due to the high level of urbanization in White Rock, runoff response to these events is typically rapid. Seasonal changes in groundwater are largely a result of changes in the area's water balance. Precipitation and evapotranspiration, coupled with the water-holding capacities of the soil, primarily determine the groundwater balance of an area. During summer, evapotranspiration exceeds precipitation and recharge potential is low; conversely, during winter precipitation exceeds evapotranspiration and recharge potential is high. Recharge in White Rock, however, has likely been reduced during the winter due to the effects of urbanization. Although major changes to the hydrological and hydrogeological function of the White Rock area have likely occurred, including decreased recharge and lowered water tables, based on the available information, it does not appear that these changes have been quantified.

## 3.2 Topography

White Rock covers a relatively small area (~550 ha) on the south side of the Semiahmoo Peninsula overlooking Semiahmoo Bay. The city limits are bounded by Bergstrom Road to the west, Stayte Road to the east, North Bluff Road to the north and the White Rock beach in Semiahmoo Bay to the south. Most of the city is situated on a steep hill slope with elevations ranging between 110 metres above sea level along North Bluff Road to sea level at the beach, as shown on **Drawing No. 1** in **Appendix A**. Based on the topographic information, the approximate average gradient of the hillslope ranges from 7% on Finlay Street to over 12% on Oxford Street, although specific areas have much higher slopes (i.e., a street sign at the base of Oxford Street indicates the road gradient up Oxford Street is 23%).The main land uses in White Rock are single and multiple family residential, with a few small parks and some commercial. There are no storm water detention facilities in the White Rock area as all storm water is managed by culverts, or flows as overland flow to the beach.

## 3.3 Geology

The surficial geology of the White Rock area is comprised primarily of Capilano Sediments (Ca-e: raised marine, deltaic and fluvial deposits), Vashon Drift (Va,b: till, glaciofluvial, glaciolacustrine and ice-contact deposits), and Pre-Vashon Deposits (PVa-h: glacial, nonglacial and glaciomarine sediments) (Geological Survey of Canada, 1977). Surficial geology of the area is shown on **Drawing No. 2** in **Appendix A**.

Within the While Rock area, the Capilano Sediments are mapped as the primarily thick (40 to 70 m) sub-unit Cd sub-unit overlain by a thinner (1 to 8 m) mantle of sub-unit Cb in isolated areas. It is likely that Cd is underlain in part by Ce, but it is not identified on the map. Cb consists of raised marine beach medium to coarse sand containing fossil marine shell casts, while Cd contains marine and glaciomarine silt loam to clay loam. Ce is mainly a marine silt loam to clay loam with marine shells. Capilano Sediments overlie the 20 to 30 m thick Vason Drift sub-unit Va along the southwest bluffs, which in turn overlie thinner exposures of Pre-Vashon deposits. Sub-unit Va consists of lodgment till with a sandy loam matrix and minor flow till containing lenses and interbeds of glaciolacustrine laminated stony silt. The Va is underlain by a) the Pre-Vashon Deposits sub-unit PVa, consisting of Quadra fluvial channel fill and floodplain deposits, cross bedded sands containing minor silt and gravel lenses, and interbeds of finer and coarser layers, and b) sub-unit PVf consisting of Semiahmoo till, glaciofluvial, glaciomarine, and glaciolacustrine deposits.

The compact till and glaciolacustrine character (primarily a blue clay) of Va is regionally important for understanding groundwater flow, as it quite often confines the underlying sandy gravelly zones of Pre-Vashon Deposits, which in this area make up the Sunnyside Uplands Aquifer.

## 3.4 Groundwater Occurrence – Aquifers

According to the BC Water Resources Atlas [BCWRA, 2009], White Rock obtains its drinking water supply from a provincially recognized sand and gravel aquifer, the Sunnyside Uplands Aquifer [Aquifer 57 II C (12)], which underlies the White Rock and surrounding South Surrey area. The atlas does not have specific details regarding the depth, thickness or other physical properties of the aquifer, but based on production well data (discussed in section 3.4), the aquifer is approximately 7 to 10 m thick and lies at and below sea level. Thus, due to the steep terrain that rises to over 100 m above sea level in the northeastern portion of the City, much of the aquifer is at substantial depths below the ground surface.

Relatively shallow perched water is also present in the Capilano Formation due to the fine-grained and compact nature of the Vashon Drift, which minimizes downward percolation. This shallow water-bearing zone is not recognized by the BC Water Resources Atlas, as it is likely limited in vertical and horizontal extent.

Aquifers in British Columbia are classified according to level of development (heavy [I] to light [III]), vulnerability (high [A] to low [C]), and ranking value component (5 [lower priority] to 21 [higher priority]), as described by MWLAP (2002). Aquifer 57 is classified as moderately developed with low vulnerability to surface sources of contamination.

Information on the status of the Sunnyside Uplands Aquifer, protection of well heads and groundwater monitoring data has been requested from EPCOR. This data would help identify trends in groundwater base levels (i.e. water table increasing or decreasing), and provide data to evaluate groundwater hydraulic gradients. As mentioned above, a comprehensive report on the City's groundwater wells is currently being prepared for EPCOR. If available, the results from this report will be integrated into the findings of this report prior to completion of the ISMP report.

## 3.5 Groundwater Hydraulics

Hydraulic conductivity is a useful measure of a soil's ability to transmit water. Values for certain soil types are documented in published literature, can be calculated from empirical relationships based on soil grain size curves and can be estimated based on field tests (Williams *et. al.*, 1998). In general, in fluvial and glacial sediments, horizontal hydraulic conductivity is greater than vertical hydraulic conductivity, so that under saturated conditions horizontally-oriented groundwater movement is generally quicker. Further, hydraulic conductivity values typically have a wide range in values that depend on soil properties (grain size, sorting, compaction, texture). For example, assuming the same hydraulic gradient and fixed cross-sectional area, a sand unit with a hydraulic conductivity on the order of $10^{-4}$ m/s will transmit two orders of magnitude more flow than a silt with hydraulic conductivity on the order of $10^{-6}$ m/s.

Table 3.1 summarizes expected ranges of hydraulic conductivity for each sub-unit mapped in the White Rock area, based on available material descriptions (Geological Survey of Canada, 1977) and published values of hydraulic conductivity (Freeze *et al*., 1979).

**Table 3.1: Estimated Hydraulic Conductivity by Material Type**

| Material Unit[1] | Geological Unit[1] | Description[1] | Estimate Range of Porosity[2] | Estimated Range of Hydraulic Conductivity[2] (m/s) |
|---|---|---|---|---|
| Cb | Quaternary Pleistocene<br>Capilano Sediments | Raised marine, deltaic, and fluvial deposits: Cb, Raised marine beach medium to coarse sand 1 to 5 m thick containing fossil marine shell casts | 10-35% in sand and gravel mixes, with increasing porosity (30-45%) in the marine and deltaic sands and silts | From $10^{-3}$ to $10^{-5}$ in sand, silt and gravel mixes to $10^{-4}$ to $10^{-6}$ in the sandy silt zones |
| Va | Quaternary Pleistocene<br>Vashon Drift | Till, glaciofluvial, glaciolacustrine and ice-contact deposits: Va, Lodgment till with sandy loam matrix and minor flow till containing lenses and interbeds of glaciolacustrine laminated stony silt | 10-25% in till, with higher porosities (25-45%) in fluvial and lacustrine units | Depending on compaction till and clay units will have a large range ($10^{-6}$ – $10^{-12}$) with relatively higher values ($10^{-4}$ – $10^{-7}$) in the glaciofluvial deposits |
| PVa,f | Quaternary Pleistocene<br>Pre-Vashon Deposits | Glacial, nonglacial, and glaciomarine sediments: Pva, Quadra fluvial channel fill and floodplain deposits, crossbedded sand containing minor silt and gravel lenses, and interbeds of fine and coarse layers: PVf, Semiahmoo till, glaciofluvial, glaciomarine, and glaciolacustrine deposits | 20-30% in channel fill, crossbedded sands and gravel lenses, with higher porosities in (30-40%) in floodplain deposits and the finer-grained interbeds | Large range in values: higher in fill, sands and gravels ($10^{-4}$ – $10^{-7}$) to relatively low values ($10^{-6}$ – $10^{-12}$) in the compact till and glaciomarine sediments |

**NOTES:**
1. Geological Survey of Canada, 1977
2.Freeze and Cherry, 1979; Driscoll, 1986.

## 3.6 Groundwater Production Wells

In addition to surficial geology maps, EPCOR, who manages the drinking water supply system for White Rock, provided borehole logs for four of the six production wells (PW #2[1], PW #3, PW #4 and PW#6). The six production wells extract approximately 2500 million litres of drinking water per year for White Rock residences. Table 3.2 summarizes the White Rock drinking water supply production well information provided by EPCOR. The production well locations are shown on **Drawing No. 1** in **Appendix A**.

[1] Although there was no well log provided for PW#1, the well log for PW#2 is noted as using the PW#1 log for the upper 84 m. PW#1 and PW#2 are located in the same general area.

**Table 3.2: White Rock Drinking Water Supply Production Wells**

| Production Well ID | Location | Geodetic Grade Elevation (masl) | Borehole Log Available | Well Construction Date |
|---|---|---|---|---|
| PW #1 | Oxford Street and Goggs Avenue | 84.6 | No | 1974 |
| PW #2 | Oxford Street and Goggs Avenue | 88.1 | Yes | 1980 |
| PW #3 | Oxford Street and Goggs Avenue | 89.6 | Yes | 1959 |
| PW #4 | High Street at Blackburn Crescent | 81.7 | Yes | 1977 |
| PW #5 | Oxford Street and Buena Vista | 10 | No | 1959 |
| PW #6 | Merklin Street and North Bluff Road | 107.8 | Yes | 1991 |

Based on our review of the production well logs provided by EPCOR and well logs available on-line from the BC Water Resources Atlas, it is likely that all the wells except PW#5 begin in the Capilano Sediments (primarly Cb, Cd and Ce), penetrate through the Vashon Drift (Va) and end in a sandy-gravelly unit (the Sunnyside Uplands Aquifer) within Pre-Vashon Deposits (PVa,f). The Capilano-Vashon contact was identified in the four wells where logs are available and is interpreted to occur, depending on well, at approximate elevations ranging from 50 to 59 masl. The base of the Vashon Drift is less defined, however, occurring at 11 masl in PW#1, 5.5 masl in PW#4 and -15.2 masl in PW#6; in PW#3 the contact could not be determined from the well log data. In wells PW#1, PW#3 and PW#4, a well-defined 2.5 to 3.0 blue clay occurs at the top of Vashon, while in PW#4 this blue clay is underlain by a very thick (34 m) gray clay. In PW#6, the blue clay was not present; however, there is a thin (< 1 m) brown clay that occurs at the base of the Capilano Formation.

In general, due to the presence of clays and compact lodgment till, the Vashon Drift is generally considered a confining unit between the more permeable Capilano and pre-Vashon deposits. This appears to be the case for the central and more western areas of White Rock where wells PW#1, PW#2, PW#3 and PW#4 are located, but is less so towards the east where PW#6 is located. Further, although there is no well log available for PW#5, based on the surficial geology map and the other well logs, PW#5 likely begins in lower Vashon sediments and is completed with Pre-Vashon deposits, thus, there are likely no confining layers protecting the aquifer at this location.

## 3.7 Groundwater Flow and Recharge

Although there are no groundwater level data, based on local topography and assumed regional groundwater flow directions, the groundwater divide for the Sunnyside Uplands Aquifer likely occurs about 1.2 to 1.8 km to the north of the coastline, on either side of 21A Avenue in South Surrey. Thus, much of the recharge area is north of North Bluff Road and outside of the city boundaries. The general groundwater flow direction within the city limits is to the south. Further, the lateral boundaries to flow (i.e., groundwater divides) are located to the east and west of the city limits. The estimated hydrographic boundary is shown on **Drawing No. 1** in **Appendix A.**

Precipitation likely infiltrates in the highlands and across much of the non-contiguous vegetated landscape within the city limits. Over much of the area, meteoric water percolates down until it encounters the fine-grained compact till or thick blue clay unit of the Vashon Drift, which has formed non-contiguous perched zones that likely emerge as small seeps on the south-facing steep slopes. In other areas, including to the north of White Rock in South Surrey and in the northeastern portion of the city, the blue clay is apparently absent, and percolation likely continues downward and recharges the aquifer. Discharge from this aquifer is to the shoreline/ocean.

Based on incomplete knowledge about the extent of the clay confining layer identified in well logs, there is a potential for a hydraulic connection between the surface and deep aquifers. This means that in certain locations where clays and compact till are absent from Vashon Drift (i.e., in vicinity of PW#6) there is a risk that infiltration of surface water (e.g., road runoff) could introduce contaminants to White Rock's drinking water source. The risk of this connection appears to be low in the vicinity of wells PW#1, PW#2, PW#3 and PW#4 due to the presence of the blue clay, while PW#5 would appear to be at higher risk because there are no overlying clay units and no readily defined till. Although the Vashon clay unit cannot be identified from the PW#6 well log, the relatively deep position of the aquifer provides some protection. Further, although the Ministry of Land and Water considers Aquifer 57 to have low vulnerability to adverse influences, additional study (i.e., borings and monitoring well installations) would be needed to confirm the lateral and vertical distribution of confining units (e.g., blue clay) in areas away from the vicinity of the existing production wells.

# 4 RECOMMENDATIONS: INFILTRATION OPPORTUNITIES AND CONSTRAINTS

Infiltration (or recharge) galleries in combination with bioswales have become a commonly promoted mitigation strategy in the region (lower mainland and western Washington) to offset the effects of urbanization, which typically results in increased stormwater runoff, reduced recharge to underlying aquifers and degraded water quality. In not all cases, however, is infiltration the best solution. For example, contaminated surface water runoff from development (primarily from roads and parking lots) could infiltrate directly into an aquifer that has no overlying low permeability clay layer (i.e., such as in the area around PW#5 and possibly PW#6) and result in negative effects to a water supply. Thus, long-term management strategies for municipalities, such as White Rock, should be developed that consider hydrogeologic conditions (varying soil properties, stratigraphy and percolation rate, and depth to aquifer), and potential percolation pathways in addition to effective stormwater design.

The management of the City's long-term reliance on groundwater puts pressure on maintaining a high quality source with sufficient quantities, yet it appears as if urbanization of the area (including White Rock and the surrounding Surrey area) has progressed without some of the necessary management tools that would reduce the risk of over production and/or reduced water quality. Thus, prudent water supply management requires that a well-defined wellhead protection program be developed. Further, the City should look to strengthening communication with EPCOR regarding the protection of the aquifer, and look to recommend, as necessary a groundwater monitoring program