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Tsawwassen First Nation Integrated Rainwater Management Plan

FINAL REPORT

URBAN systems

INTEGRATED RAINWATER MANAGEMENT PLAN

PREPARED FOR: Tsawwassen First Nation

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USL File # 2177.0040.01

URBAN systems

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Executive Summary

An Integrated Rainwater Management Plan (IRMP) is a comprehensive plan that examines the interrelationships between drainage servicing, land use planning, and environmental protection. Its purpose is to outline an approach to support and promote the growth of a community in a way that maintains, or ideally enhances, the overall health of a watershed. By applying an integrated approach, an IRMP can be used to link watershed and stream health to land use and policy decisions. Further, as a policy level document, an IRMP can be a powerful tool that supports a community's path towards achieving its vision for the future.

Tsawwassen First Nation (TFN) is poised to experience considerable growth and development over the next few decades. This growth will directly result in the need to provide improved drainage services and protect environmental assets, all while allowing development to proceed. The IRMP provides the opportunity for TFN to outline its rainwater management goals and objectives, in a proactive manner, to guide future development. It also satisfies TFN's commitments under the existing services agreements between TFN and the Corporation of Delta (Delta), and has been prepared in accordance with Metro Vancouver's Integrated Liquid Waste and Resource Management Plan requirements.

TFN lands are situated next to the Strait of Georgia (Salish Sea) and are bordered by Delta on the north, east and south sides. TFN lands are bisected near the north and south limits by the Port Metro Vancouver Roberts Bank Causeway (Deltaport Way) and the BC Ferries Causeway (Highway 17A), respectively. The total area of TFN lands (post-Treaty; as of September 2011) is 662 hectares (ha) (identified as the "Tsawwassen Lands" in the TFN Land Use Plan).

While the scope of the IRMP mainly focuses on TFN lands, it is important to understand how TFN lands interact with and are affected by the surrounding area. Therefore, the IRMP also considers external lands that are hydraulically connected to TFN; that is, rainwater runoff generated by these external lands is conveyed through TFN lands and discharged to the Strait of Georgia. The external lands are located within Delta and are roughly bounded by Deltaport Way to the north, Boundary Bay to the east, 14 Avenue to the south, and 52 Street to the west. TFN lands and external lands together comprise the Study Area for the IRMP (approximately 1,716 ha in total).

The IRMP has been organized into four stages; the purpose and outcomes of each stage is highlighted in Table E.1 below.

Table E.1: IRMP Stages

STAGE	TITLE	PURPOSE AND OUTCOMES
Stage 1	What Does TFN Have? (Inventory of Existing Systems)	• Summarize key features and properties of the Study Area • Highlight opportunities and constraints • Identify key issues for the IRMP to address

STAGE	TITLE	PURPOSE AND OUTCOMES
Stage 2	What Does TFN Want? (Vision, Goals and Objectives)	• Summarize anticipated future land uses in the Study Area • Articulate a vision (supported by goals and objectives) for rainwater management that meets community needs and guides the IRMP process
Stage 3	How Does TFN Put The IRMP Into Action? (Assessment, Analysis and Implementation)	• Identify, assess and present the recommended servicing approach(es) for future development conditions • Outline performance targets and design criteria • Develop a clear framework for implementation • Prepare cost estimates for recommended works
Stage 4	How Does TFN Ensure That The IRMP Stays On Target? (Monitoring and Adaptive Management)	• Identify performance indicators for key IRMP components • Outline monitoring and assessment programs • Describe an adaptive management process that TFN can use to modify the implementation strategy if, through monitoring and assessment program results, TFN determines that the IRMP vision, goals and objectives are not being met

Stage 1 – What does TFN have?

The IRMP provides an inventory of existing systems, including drainage infrastructure (open ditches, culverts, sewers, pump stations and dikes), land use, regulatory framework (laws and regulations, service agreements), environmental features (aquatic and foreshore habitat, wildlife, vegetation), geotechnical (soil characteristics, slope stability), hydrogeology (groundwater and aquifer), and water and sediment quality.

The majority of TFN lands are currently undeveloped or used for agricultural purposes, with remaining lands consisting of housing, community facilities and limited commercial uses. The remainder of the Study Area primarily consists of agricultural lands, although residential, recreational (golf courses) and commercial uses are also present. There are several future developments planned on TFN lands, which will result in an increase in impervious (hard surface) area in the order of 260 hectares over existing conditions. Per Delta's Official Community Plan (OCP), Delta will only experience a 19 hectare increase in impervious area under future conditions.

The regulatory framework varies depending on whether lands are located within TFN or Delta. Regional, Provincial and Federal statutes and regulations may also be relevant. In general, TFN Regulations and Delta Bylaws cover many of the same topics; however, TFN's Regulations tend to be broader in scope and definition whereas Delta Bylaws tend to be more defined and prescriptive.

The drainage network within the lowland portions of the Study Area primarily consist of interconnected ditches, with culverts at road and driveway crossings. The network collects and conveys rainwater and irrigation runoff to pump stations, which in turn discharge flows to the Strait of Georgia. In the upland portions of the Study Area, the drainage network generally consists of an underground storm sewer system, with limited segments of roadside ditching.

TFN lands are currently protected from ocean inundation by a dike system that separates the community from the Strait of Georgia. The existing dike system generally meets current Provincial flood protection requirements; however, recently published Provincial documents on climate change adaptation suggest that flood protection infrastructure on TFN lands may need to be altered significantly over the next several decades to respond to climate change.

From an environmental perspective, the ditches in the Study Area are channelized and straight, have poor water quality characteristics, contain no characteristic features of salmonid-bearing stream habitat, and largely function as a conveyance network for the surrounding lands and road system. By contrast, the foreshore marine environment (to which the internal drainage network discharges to) contains high value habitat for birds, fish and other wildlife.

The majority of vegetated areas within TFN lands consist of cultivated agricultural or fallow lands, with stands of trees on the Tsawwassen Bluff escarpment and along larger drainage ditches. Watercourses and associated riparian habitat have been substantially modified since settlement and development of agriculture. Remaining riparian habitat is of important ecological value as it provides habitat for a variety of mammal and bird species, stabilizes ditch banks, and filters runoff from adjacent lands.

TFN lands provide habitat for a variety of wildlife species including those associated with marine, intertidal, grassland, riparian and forest habitat types. The Study Area supports amphibians (frogs, salamanders), garter snakes, a wide variety of birds, mammals (mice, beavers, coyotes, raccoons) and invertebrate species. TFN lands, adjacent farmland and foreshore have been identified as an Important Bird Area (IBA); approximately 264 bird species have been documented within the Boundary Bay – Roberts Bank – Sturgeon Bank IBA.

Within the lowland portions of the Study Area, the natural soil conditions likely consist of a thin layer of topsoil, overlying up to about 3 metres of silt to clayey silt, overlying about 50 metres of interlayered sand and silt layers. Some areas have been previously filled, and the quality and composition of such fill has not been characterized, although is likely highly variable. The water table is high and is likely near the surface of the natural soils during the wetter months or when irrigated. Groundwater flow directions are complex as they are dependent on the water levels in the ditches (which are controlled by the pump stations) and the water levels in the ocean relative to the water table elevation in the soil.

Within the upland portions of the Study Area, the steep slopes of the Tsawwassen Bluffs are subject to a slow process of sloughing and slope regression that is expected to continue. Groundwater seepage discharge is common on the slopes at and near the slope toe of the escarpment. This contact and seepage discharge forms the initiation zones of active shallow debris slides.

A limited water and sediment quality sampling program was conducted as part of the IRMP. Measured levels of dissolved oxygen and total suspended solids suggest that these parameters are limiting factors for fish in local ditches. There were exceedances for some chemical and bacteriological water quality samples, as well as exceedances for total organic carbon, metals, and hydrocarbon constituents in sediment samples.

Based on the inventory of existing systems in the Study Area, the key issues identified to consider in the IRMP are:

- Conveyance and Pumping
- Water Quality
- On-Lot Rainwater Retention
- Flood Protection

Stage 2 – What does TFN want?

TFN's location, the surrounding natural environment, and the community's connection to the land and the ocean all lend themselves to the opportunity to showcase sustainable and innovative approaches to rainwater management. Through discussions with TFN Staff, Council and Community Members, a Vision for Integrated Rainwater Management on TFN lands has been developed:

Tsawwassen First Nation's (TFN) approach to Rainwater Management supports and promotes the balanced growth of the community in a way that positively contributes to the overall health of the surrounding environment. Rainwater is viewed as a resource, and development capitalizes on the opportunities to implement innovative Rainwater Management techniques while providing effective drainage service that does not impede the use and enjoyment of adjacent lands by others.

The collective Rainwater Management system allows the surrounding environment to thrive, supporting wildlife, aquatic species, and vegetation by providing habitat, food and migration routes. TFN's historic connection to the land and the sea is reflected through the proliferation of naturalized drainage systems throughout the community. Aside from their intended functions, these systems also act to educate and inform community members of the importance of Rainwater to humans and the natural environment. TFN is proud of the example that the community has set towards Rainwater Management.

This vision is supported by several goals and objectives related to rainwater management, environment, geotechnical, planning and land use, and landscape.

Stage 3 – How does TFN put the IRMP into action?

The IRMP assessed the hydrological characteristics of TFN lands and the overall Study Area, along with the hydraulic performance of the drainage infrastructure that services those lands under existing and future land use conditions. Various scenarios have been assessed their ability to adequately service the TFN community and maintain a comparable level of drainage service (as compared to existing

development conditions) to the overall Study Area. Climate change (sea level rise, rainfall pattern distribution changes) and land subsidence has been considered as part of the future servicing analyses.

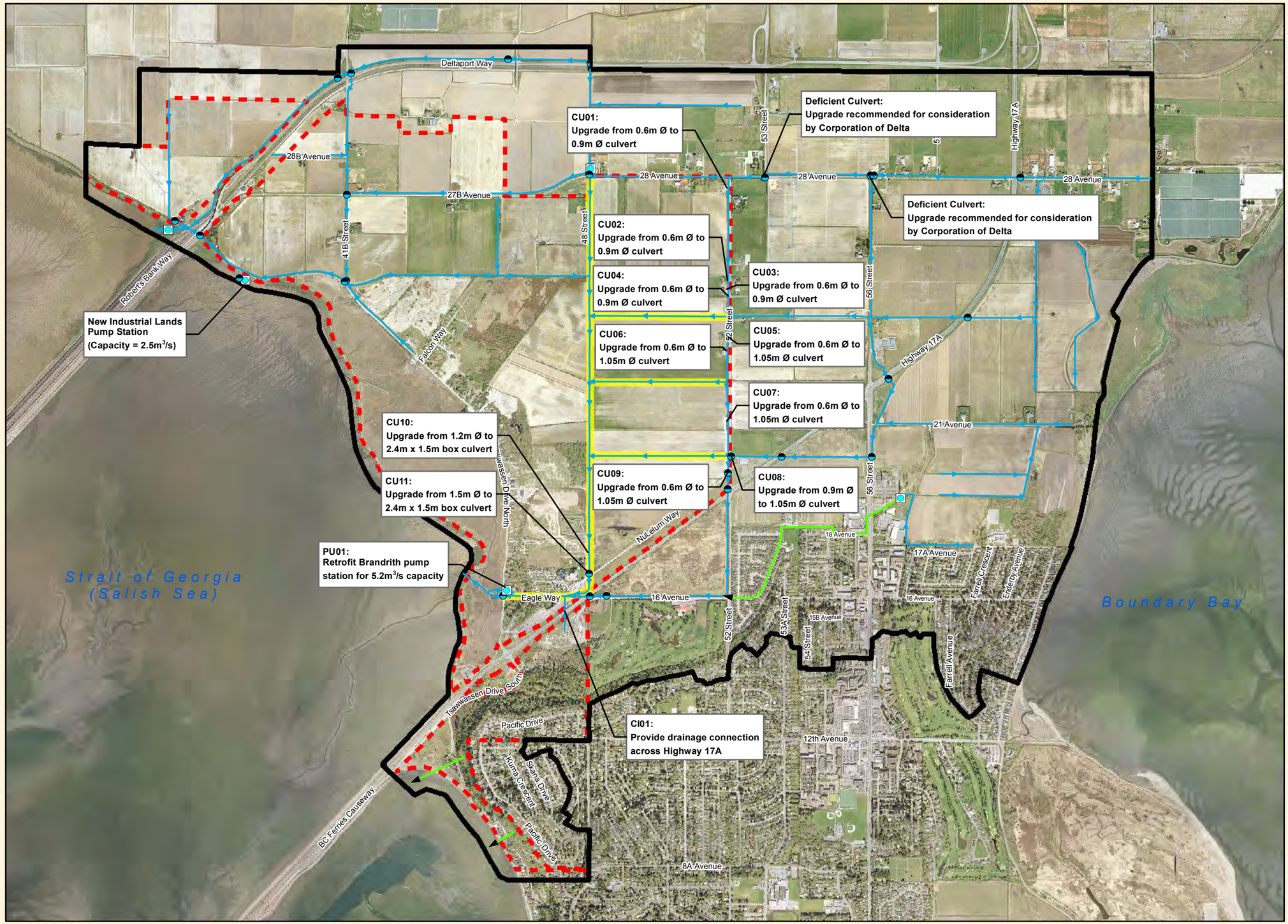
The recommended servicing approach (Figure ES.1) to support future growth and development on TFN lands and the overall Study Area consists of the following:

- Increase total capacity of Brandrith Drainage Pump Station from 2.8 m^3/s to 5.2 m^3/s (plus existing jockey) by retrofitting the existing station
- Construct a new drainage pump station for the TFN Industrial Lands with a pumping capacity of 2.5 m^3/s
- Upgrade several culverts along the 48th Street and 52nd Street drainage channels to increase conveyance capacity
- Provide 300mm depth of amended topsoil in all pervious areas within new development (both private and public areas)
- Disconnect impervious areas to the greatest extent possible (e.g., discharge roof downspouts to splash pads for single family and multi-family residential development, grade sites to drain impervious areas to pervious areas)
- Maximize opportunities to decrease impervious surfaces (e.g., reduce road widths and parking areas, use porous paving materials for driveways, patios, parking pads, on-street parking areas, etc.)
- Review opportunities to retain rainwater runoff generated by impervious surfaces though the use of rainwater management features (RMFs) including rain gardens, vegetated bioswales, rainwater harvesting techniques, etc.

Cost estimates for recommended drainage infrastructure, summarized in Table E.2 below, are representative of Class D cost estimates and include 35% contingency and 12% engineering, but exclude GST.

Table E.2: Recommended Drainage Infrastructure – Construction Cost Estimates

ITEM	TOTAL
Retrofit Brandrith Drainage Pump Station for 5.2m^3/s capacity	$ 1,259,000
TFN Industrial Lands Drainage Pump Station (2.5 m^3/s capacity)	$ 2,498,000
CI01: Provide drainage connection across Highway 17A (allowance)	$500,000
CU01: Upgrade existing 600mm to 900mm HDPE Culvert	$ 56,000
CU02: Upgrade existing 600mm to 900mm HDPE Culvert	$ 47,000
CU03: Upgrade existing 600mm to 900mm HDPE Culvert	$ 47,000
CU04: Upgrade existing 600mm to 900mm HDPE Culvert	$ 50,000
CU05: Upgrade existing 600mm to 1050mm HDPE Culvert	$ 46,000



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Legend

- Modeled Culverts
- Modeled Pump Stations
- Modeled Ditch Network
- Modeled Pipe Network
- Watercourses identified within the Drainage and Irrigation Services Agreement.
- Tsawwassen First Nation (TFN) lands
- IRMP Study Area

Note: Orthophoto on west half of figure was taken on July 31, 2013.
Orthophoto on east half of figure was taken in 2008.

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Integrated Rainwater Management Plan Recommended Drainage Infrastructure Improvements

Figure ES.1

0 250 500 1,000
Meters

U:\Projects_VAN\2177\0040\01\D-Drafting-Design-Analysis\GIS\Projects\MXD\Current\ModelUpdate_November2013\Figure ES.1 - Recommended Drainage Infrastructure Improvements.mxd Last updated by: bpauls on December 18, 2013 at 3:47:29 PM

ITEM	TOTAL
CU06: Upgrade existing 600mm to 1050mm HDPE Culvert	$ 46,000
CU07: Upgrade existing 600mm to 1050mm HDPE Culvert	$ 50,000
CU08: Upgrade existing 900mm to 1050mm HDPE Culvert	$ 61,000
CU09: Upgrade existing 600mm to 1050mm HDPE Culvert	$ 102,000
CU10: Upgrade existing 1200mm to 2.4m x 1.5m Box Culvert	$ 132,000
CU11: Upgrade existing 1500mm to 2.4m x 1.5m Box Culvert	$ 147,000
Subtotal	**$ 5,041,000**
35% Contingency	$ 1,764,000
12% Engineering	$ 605,000
TOTAL	**$ 7,410,000**

Works could be funded through TFN's offsite levies (OSL) program, or through a future rainwater management utility, depending on the nature of the work, the benefitting area, and TFN's preference for cost recovery.

Three tiers of water quality treatment are recommended for future development:

- Basic Control – focuses on removal of total suspended solids (with associated pollutants that are attached to those sediments)
- Oil Control – focuses on removal of petroleum hydrocarbons
- Enhanced Control – focuses on removal of dissolved metals (e.g., copper and zinc)

The level of water quality treatment to be applied will depend on the proposed land use.

Future development at TFN also provides an opportunity to incorporate wildlife movement linkages into the landscape. Environmental enhancement efforts should focus on wildlife habitat improvements and linkages, which in turn should also improve habitat conditions for non-salmonid fish species that may be present in the ditch network. Developments should maintain aquatic habitat where feasible, with priority given to retention of Class A ditches. Compensation for habitat lost due to ditch infilling can best be achieved by designating specific areas for newly created habitat, and placing these within or adjacent to larger retained or managed habitat.

Opportunities to achieve multiple goals and objectives through shared spaces should be explored. In particular, applying a multi-functional corridor network approach to roadways (48th Street, local roads) and the proposed Great Blue Heron Way is encouraged. These spaces should strive to achieve drainage, environmental and landscape goals and objectives.

The IRMP also identifies a suite of regulatory amendments and additions to enhance TFN's support of integrated rainwater management. High priority regulatory amendments and additions are listed in Table E.3.

Table E.3: High Priority Regulatory Amendments and Additions

	RECOMMENDATIONS
1.	Finalize the MMCD Design Guideline Manual and Construction Specifications – Supplementary Specifications document
2.	Amend the Drainage and Sewer Regulation
3.	Establish an Erosion and Sediment Control Regulation
4.	Update the Capital Plan
5.	Update the Offsite Levies Regulation
6.	Amend the Landscape Guidelines

With sea levels predicted to rise and land predicted to subside (sink) in the future, the current flood protection (dike) system will not be adequate to protect the TFN community in the long-term. Therefore, options to provide improved flood protection to the community should be explored. Building on the IRMP, TFN should undertake a flood protection study to review and assess the suitability of various alternatives for providing flood protection to the TFN community in the future. In-depth drainage studies for TFN's community lands and the Tsawwassen Bluffs area are also recommended to resolve specific drainage concerns with these areas.

Stage 4 – How does TFN ensure that the IRMP stays on target?

Performance indicators and targets are needed to evaluate proposed development schemes and to determine the level of success in achieving the IRMP goals and objectives. Primary performance indicators and targets are listed in Table E.4.

Table E.4: IRMP Performance Indicators and Targets

PERFORMANCE INDICATOR	TARGET
Frequency and Extent of Flooding	Not to exceed current levels
Water and Sediment Quality	Stabilize, or ideally improve, over current conditions
Open Channel Riparian Health	Minimum 80% survival rate of native (existing or planted) vegetation Minimize / remove invasive species within riparian zones

The IRMP outlines a comprehensive monitoring program to assess the ability of future development to meet the IRMP vision, goals and objectives as works and programs are implemented. Precipitation, water levels, flow rates, water and sediment quality, riparian habitat, and intertidal and marine habitat condition monitoring are all recommended, along with annual assessments and reporting. Approximately $150,000 is required to establish the monitoring programs and conduct an initial year's review. Approximately $30,000 to $40,000 per year is estimated to maintain the programs thereafter. This excludes TFN's internal costs associated with administration and records.

The IRMP also outlines an adaptive management framework to assist in identifying issues and outlining corrective actions should the monitoring program results indicate that IRMP goals and objectives are not being met.

1.0 Introduction

1.1 Study Area Description

Tsawwassen First Nation (TFN) lands are situated next to the Strait of Georgia (Salish Sea) and are bordered by the Corporation of Delta (Delta) on the north, east and south sides, as shown on Figure 1.1. TFN lands are bisected near the north and south limits by the Port Metro Vancouver Roberts Bank Causeway (Deltaport Way) and the BC Ferries Causeway (Highway 17A), respectively. The total area of the TFN lands (post-Treaty; as of September 2011) is 662 hectares (ha) (identified as the "Tsawwassen Lands" in the TFN Land Use Plan).

While the scope of this Integrated Rainwater Management Plan (IRMP) mainly focuses on the TFN lands, it is important to understand how TFN lands interact with and are affected by the surrounding area. Therefore, the IRMP also considers external lands that are hydraulically connected to TFN; that is, rainwater runoff generated by these external lands is conveyed through TFN lands and discharged to the Strait of Georgia. The external lands are located within Delta and are roughly bounded by Deltaport Way to the north, Boundary Bay to the east, 14 Avenue to the south, and 52 Street to the west. TFN lands and external lands together comprise the Study Area for the IRMP (approximately 1,716 ha in total). The Study Area boundary is shown on Figure 1.1.

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Legend

- Tsawwassen First Nation (TFN) lands
- IRMP Study Area

Note: Orthophoto on west half of figure was taken on July 31, 2013.
Orthophoto on east half of figure was taken in 2008.

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Integrated Rainwater Management Plan

Study Area

Figure 1.1

0 250 500 1,000
Meters

U:\Projects_VAN\2177\0040\01\D-Drafting-Design-Analysis\GIS\Projects\MXD\Current\ModelUpdate_November2013\Figure 1.1 - Study Area.mxd Last revised by bpauls on 18/12/2013 at 3:05:43 PM

1.2 What is an Integrated Rainwater Management Plan (IRMP)?

An Integrated Rainwater Management Plan (IRMP) is a comprehensive plan that examines the interrelationships between drainage servicing, land use planning, and environmental protection. Its purpose is to outline an approach to support and promote the growth of a community in a way that maintains, or ideally enhances, the overall health of a watershed. By applying an integrated approach, an IRMP can be used to link watershed and stream health to land use and policy decisions. Further, as a policy level document, an IRMP can be a powerful tool that supports a community's path towards achieving its vision for the future.

1.3 Why is an IRMP Required for Tsawwassen First Nation (TFN)?

TFN is poised to experience considerable growth and development over the next few decades. This growth will directly result in the need to provide improved drainage services and protect environmental assets, all while allowing development to proceed. The IRMP provides the opportunity for TFN to outline its rainwater management goals and objectives, in a proactive manner, to guide future development.

TFN is also a member of Metro Vancouver. Metro Vancouver (through the Greater Vancouver Sewerage and Drainage District (GVS&DD) has prepared an Integrated Liquid Waste and Resource Management Plan (ILWRMP) that requires members to prepare IRMPs for their watersheds. While not currently a member of the GVS&DD, TFN has considered the ILWRMP requirements in the preparation of this IRMP.

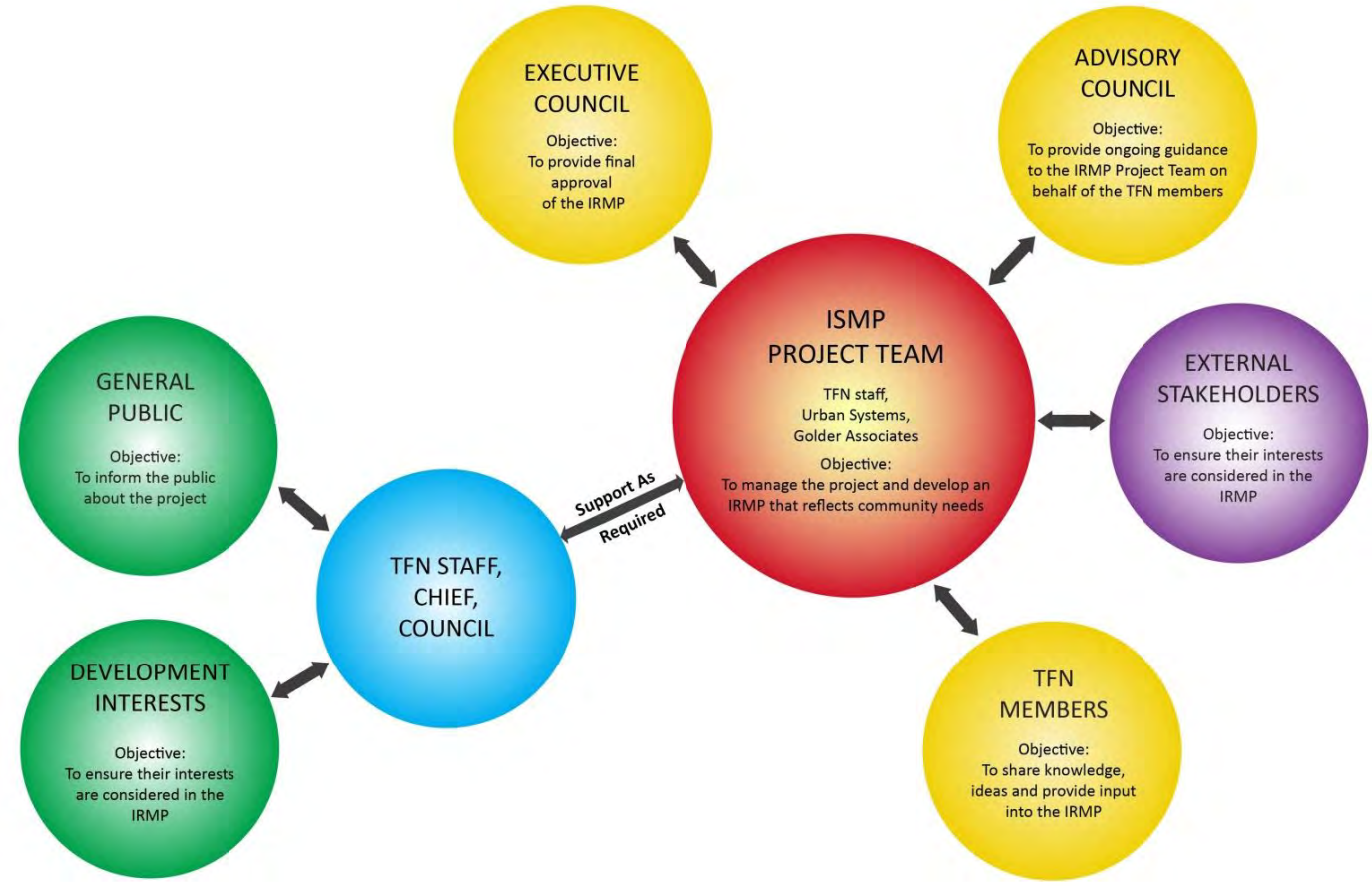
Finally, the existing Drainage and Irrigation Services Agreement (Section 9) between TFN and Delta states that TFN shall develop a "Master Drainage Plan for TFN Lands". This IRMP also satisfies this requirement.

1.4 Communication and Consultation Strategy

A communication and consultation strategy was implemented throughout the IRMP process, focusing on five principle audiences; TFN staff and Council, TFN members, development interests, external stakeholders and the general public. Figure 1.2 illustrates the communication and consultation approach utilized for the IRMP. The detailed communication and consultation plan is included in Appendix B.

Communication and consultation formats for TFN included presentations to the Executive and Advisory Councils, review meetings with staff, monthly progress updates, and other means to actively seek responses and feedback to various elements of the IRMP. TFN membership was engaged through open houses and feedback forms, along with family meetings on an as-requested basis. Project updates were also published in the Community Notice, which is posted on TFN's website.

Figure 1.2: Communication and Consultation Flowchart



There are active development interests in various stages of planning, design and implementation for proposed developments on TFN lands. In-person meetings and other correspondence was provided to developer design teams on an as-requested basis to provide relevant information. TFN also engaged development interests at a high level to periodically seek feedback on key IRMP themes and recommendations.

There are several external stakeholders who may have an interest in the TFN IRMP. Stakeholders identified and engaged through the IRMP include:

- Corporation of Delta
- Fisheries and Oceans Canada (DFO)
- Port Metro Vancouver
- Delta Farmer's Institute
- Ministry of Transportation and Infrastructure (MOT)
- Agricultural Land Commission (ALC)

- Delta Farmland and Wildlife Trust
- BC Rail
- BC Ferries
- Fraser River Port Authority

External stakeholders were notified at the onset of the project and relevant background information was requested. In-person meetings were also held during the IRMP process on an as-requested basis. Contact information for external stakeholders is provided in Appendix B.

While not considered external stakeholders for the IRMP, the following organizations were also contacted to obtain relevant background information:

- BC Ministry of Agriculture
- Canadian Hydrographic Service – Pacific Region (Institute of Ocean Sciences)
- Pacific Field Corn Association (Farmwest)

Contact information is provided in Appendix B.

1.5 Report Outline

The IRMP has been organized into four stages; the purpose and outcomes of each stage is highlighted in Table 1.1 below.

Table 1.1: IRMP Stages

STAGE	TITLE	PURPOSE AND OUTCOMES
Stage 1	What Does TFN Have? (Inventory of Existing Systems)	• Summarize key features and properties of the Study Area • Highlight opportunities and constraints • Identify key issues for the IRMP to address
Stage 2	What Does TFN Want? (Vision, Goals and Objectives)	• Summarize anticipated future land uses in the Study Area • Articulate a vision (supported by goals and objectives) for rainwater management that meets community needs and guides the IRMP process
Stage 3	How Does TFN Put The IRMP Into Action? (Assessment, Analysis and Implementation)	• Identify, assess and present the recommended servicing approach(es) for future development conditions • Outline performance targets and design criteria • Develop a clear framework for implementation • Prepare cost estimates for recommended works
Stage 4	How Does TFN Ensure That The IRMP Stays On Target? (Monitoring and Adaptive Management)	• Identify performance indicators for key IRMP components • Outline monitoring and assessment programs • Describe an adaptive management process that TFN can use to modify the implementation strategy if, through monitoring and assessment program results, TFN determines that the IRMP vision, goals and objectives are not being met

2.0 What Does TFN Have?

2.1 Regulatory Framework

Within the IRMP Study Area, the regulatory framework varies depending on whether lands are located within TFN or the Corporation of Delta. Each jurisdiction has a number of policies, laws/bylaws, and regulations that directly or indirectly affect or provide direction for rainwater management. Regional, Provincial and Federal statutes and regulations may also be relevant. The following summarizes the existing regulatory framework for the IRMP.

2.1.1 Tsawwassen First Nation

TFN is in a unique position as it is a Treaty First Nation, with its own unique Constitution, Laws, and Regulations. As they relate to rainwater management, key aspects of these laws and regulations are highlighted below.

Land Use Planning and Development Act

Since the enactment of the TFN Treaty, the *TFN Land Use Planning and Development Act* establishes the legal framework for the management of lands, including the enactment of a Land Use Plan, Zoning Regulation, Subdivision and Development Regulation, and other regulations pertaining to development and the overall use of land.

Land Use Plan

Adopted in 2008, the TFN Land Use Plan sets the overall policy direction for TFN land use. All TFN regulations must be consistent with the Land Use Plan, and any amendments to the Land Use Plan require the approval of a majority community vote, as stipulated in the *TFN Land Use Planning and Development Act.* The Land Use Plan contains several policies relevant to rainwater management. It

supports the creation of a “Blue Ways” system, based on existing drainage patterns, and it supports the acquisition of rights-of-ways for trails and parks during the development approvals process. The Plan supports the use of drought resistant landscaping to assist with water conservation, and it also supports the use of alternative road standards for all development, including narrower rights-of-ways, permeable surfaces with street trees and lower speed roads. The use of vegetated bioswales and rainwater retention ponds are encouraged to minimize run-off and reduce the need for an extensive underground storm sewer system.

Enterprise Area Neighbourhood Plan

The Enterprise Area Neighbourhood Plan (2011) establishes the overall land use direction for approximately 110 ha of primarily Tsawwassen Fee Simple Interest (TFSI) lands, centered on the area designated as “residential/commercial enterprise” in the TFN Land Use Plan. The Enterprise Area Neighbourhood Plan has a number of relevant drainage features. The Plan also calls for the development of a “Great Blue Heron Way” multi-purpose trail, other greenways, an improved connection to the Tidal Marsh, and an emphasis on quality public realm that celebrates TFN culture.

The Plan notes that “‘prior to completion of the IRMP, development proponents should be aware that stormwater detention or water quality facilities may be required, which potentially could have an impact on surface uses.” The neighbourhood plan makes no recommendation on how these facilities would be dedicated. Approximate locations for detention facilities are identified in the Plan. Additionally, vegetated bioswales are shown on road cross-sections outside the Village Centre area, with all road cross-sections being subject to engineering review.

Zoning Regulation

The Zoning Regulation deals with land use, facility siting, development densities, parking requirements and more. Zoning regulations have an impact on the extent of impervious surfaces on a given parcel of land, most notably through minimum parking space requirements and through maximum parcel coverage and/or setback requirements. The Zoning Regulation also stipulates minimum setbacks from water bodies and watercourses (i.e., 15 metre setback from the boundary of any non-fish bearing watercourse and 30 metre setback from the boundary of any fish-bearing watercourse).

Development Permit Guidelines Regulation

The Development Permit Guidelines Regulation mandates the issuance of a development permit prior to: subdivision of land; alteration of land, including but not limited to clearing, grading, filling, blasting, preparation for the construction of services and roads; and/or, construction of, addition to or alteration of a building or structure. TFN’s Executive Council has the authority to impose development permit conditions on a wide range of issues, including servicing requirements, areas of land to remain free of development, dedication requirements, and more. Development permit guidelines specifically require the completion of a professional report to determine the impacts of a development proposal on stormwater management (among other topics).

Subdivision and Development Regulation

The Subdivision and Development Regulation deals with the provision of works and services in relation to the subdivision and development of land. The Regulation includes a requirement for parcel holders to "provide…drainage works including surface and underground collection, conveyance and treatment systems," designed by a Professional Engineer in accordance with Master Municipal Construction Document (MMCD) Design Guideline Manual, the MMCD Specifications and Standard Drawings, and any supplementary TFN design criteria, specifications and standard drawings as issued and amended from time to time.

Drainage and Sewer Regulation

Under TFN's Community Governance Act, the Drainage and Sewer Regulation prohibits the discharge of wastewater into a storm sewer or the community drainage system without prior authorization. It also prohibits the discharge of any substance or thing that might obstruct, interfere with, damage or injure a storm sewer or the community drainage system, or its ability to be maintained or repaired.

Soil Transport, Deposit and Removal Regulation

Also under TFN's Community Governance Act, the Soil Transport, Deposit and Removal Regulation sets out the requirements for the transport, deposit or removal of soil on TFN lands. It requires the importation of clean fill and outlines additional requirements where removal or deposit activities could potentially result in an alteration or diversion of a natural watercourse, or in any harm to fish habitat. Interim and permanent drainage plans, prepared by a Professional Engineer, are required to show how potential impacts on adjacent lands due to proposed deposit and/or removal activities shall be avoided or minimized.

Offsite Levies Regulation

The Offsite Levies (OSL) Regulation sets out levies required to be paid to TFN as a condition of a subdivision or building permit, with fees used to fund community infrastructure elements that support development. OSLs are not applicable to RS1 zoned lands as defined by the Zoning Regulation, or where four or fewer lots are being subdivided as part of one application.

2.1.2 Corporation of Delta

Within the Corporation of Delta, there are a number of policies, bylaws, and regulations that have an impact on the approach to rainwater management. Relevant features are described in brief below.

Official Community Plan (OCP)

Delta's OCP Bylaw establishes the policy context for land use, similar to the TFN Land Use Plan. Delta's OCP contains a number of rainwater-related policies, including statements to:

- Work with agencies to manage and monitor point source pollution and non-point source pollution sources;
- Utilize integrated rainwater management practices consistent with the regional Liquid Waste Management Plan;
- Maintain water quality in groundwater aquifers;
- Promote best management practices (e.g., limit and mitigate impervious area);
- Utilize infiltration devices, open ditches, and alternative/innovative street edge design (where appropriate);
- Explore the use of alternative development standards; and,
- Mitigate negative environmental impacts of rainwater runoff.

Schedule E of the OCP also includes Development Permit Area guidelines and requirements for three areas within the Study Area: entrance to Tsawwassen (56 Street), the Tsawwassen Bluffs, and the Tsawwassen Golf & Country Club. Requirements for these areas relate to flood protection, protecting the natural environment, protecting development from hazardous conditions through siting and design controls, and encouraging the use of best management practices including green roofs, rainwater capture and reuse for irrigation, maximizing landscape areas and using permeable surfaces. Schedule E also identifies a Streamside Protection and Enhancement Development Permit Area, which applies to all lands that are partly or entirely located within 30 metres from the top of bank of a "stream" (defined as a watercourse or source of water supply, whether it usually contains water or not). Its purpose is to preserve, protect, restore and enhance fish and wildlife and their habitats.

Tsawwassen Area Plan

The Tsawwassen Area Plan was updated and adopted in April 2011. The plan contains relevant policies to protect farms and other properties from deterioration caused by changes in drainage patterns or water table levels, and to upgrade the drainage system as required to accommodate new development.

Zoning Bylaw

As with TFN's Zoning Regulation, Delta's Zoning Bylaw deals with the use of land, siting of facilities, density of development, parking requirements, and more. These zoning regulations have an impact on the extent of impervious surfaces on a given parcel of land, most notably through minimum parking space requirements and through maximum parcel coverage and/or setback requirements.

Subdivision and Development Standards Bylaw

The Subdivision and Development Standards Bylaw provides the basis for drainage (and stormwater) design throughout the municipality. In the South Delta area, drainage systems and stormwater management plans are to be designed in accordance with the provisions of the "South Delta, Boundary Bay Drainage Area and Georgia Strait Drainage Area, Master Drainage Plan" (May 1990), the "Ladner Master Drainage Plan" (1994) and the "Stormwater Management Design Manual" (1994) as amended from time to time.

Waterways Protection Bylaw

The Waterways Protection Bylaw prohibits fouling, obstructing or impeding flow of any stream, creek, waterway, watercourse, waterworks, ditch, drain or sewer within the municipality. It also prohibits the cutting, destroying or injuring of dikes or other drainage or reclamation works that serve as part of the municipal drainage system.

Soil Removal and Deposit Regulation Bylaw

The Soil Removal and Deposit Regulation Bylaw regulates, prohibits, or requires the holding of a permit for the removal of soil from, and the deposit of soil or other material on, any land in the municipality. It sets out requirements for filling land to achieve flood protection levels for building construction, and requires that a lot grading plan be prepared to address drainage issues. The bylaw also prohibits the obstruction and/or damage to any drainage facility, watercourse, or groundwater aquifer due to soil removal or deposit activities.

Since the Study Area encompasses both TFN lands and Delta lands, it is important to review and compare the regulations and bylaws that have been enacted by TFN and Delta, respectively, to understand the similarities and differences in how rainwater-related regulations and bylaws have been developed and implemented. Table 2.1 identifies the key similarities and differences between rainwater-related regulations established by TFN and Delta.

Table 2.1: TFN Regulation and Delta Bylaw Comparison

REGULATION / BYLAW	SIMILARITIES /DIFFERENCES
Land Use Plan (TFN) **Official Community Plan (OCP) (Delta)**	There is a comprehensive set of Objectives and Policies incorporated in Delta's *OCP*, specifically related to Fish and Wildlife Habitat, and Water and Foreshore Protection. The Guiding Planning Principles contained in TFN's *Land Use Plan* provide a much broader, or "higher level" of direction. For example, the TFN *Land Use Plan*'s Planning Principle most relevant to the IRMP is to "Embrace Environmental Sustainability". In terms of development, it is stated in the "Community Services" section of TFN's *Land Use Plan* that 'TFN supports the upgrading of the drainage network on the Tsawwassen Lands and that a drainage plan will be required with any development application.'

REGULATION / BYLAW	SIMILARITIES /DIFFERENCES
Zoning Regulation (TFN) **Zoning Bylaw (Delta)**	TFN's *Zoning Regulation* includes provisions regarding setbacks from water bodies and watercourses. Such provisions are not contained in Delta's *Zoning Bylaw;* instead, Delta's watercourse setbacks are outlined in their *Development Permit Area For Streamside Protection and Enhancement Guidelines*.
Subdivision and Development Regulation (TFN) **Subdivision and Development Standards Bylaw (Delta)**	Design criteria contained within TFN's *Subdivision and Development Regulation* are in accordance with the latest edition of the Master Municipal Construction Document (MMCD) and TFN's Supplementary Specifications. Delta has developed its own Design Criteria Manual, contained within the *Subdivision and Development Standards Bylaw*, which outlines the minimum requirements and standards the Municipality will accept for works and services.
Soil Transport, Deposit and Removal Regulation (TFN) **Soil Removal and Deposit Regulation Bylaw (Delta)**	TFN's *Soil Transport, Deposit and Removal Regulation* requires that Permit Holders maintain general liability insurance and provide a security deposit as conditions of the permit. The regulation also provides clear direction on enforcement of permit requirements, as well as outlining working hours and fees. The regulation is similar to other bylaws of this type for communities in the Lower Mainland, including Delta's *Soil Removal and Deposit Regulation Bylaw.*
Drainage and Sewer Regulation (TFN) **Waterways Protection Bylaw (Delta)** **Sanitary Sewer Use Regulation and Connection Charge Bylaw (Delta)** **Storm Sewers Regulation and Connection Charge Bylaw (Delta)**	TFN has included all stipulations regarding the drainage and sewer system in the *Drainage and Sewer Regulation* while Delta has three (3) separate bylaws that regulate the sanitary sewers, storm sewers and the protection of Delta's waterways.

In general, TFN Regulations and Delta Bylaws cover many of the same topics; however, TFN's Regulations tend to be broader in scope and definition whereas Delta Bylaws tend to be more defined and prescriptive.

2.1.2.1 Service Agreements

Drainage and Irrigation Services Agreement

TFN and Delta currently have a Drainage and Irrigation Services Agreement in place, which outlines maintenance responsibilities for the existing drainage system on TFN lands, as well as cost sharing arrangements for new drainage infrastructure. Ditches are currently inspected and maintained (i.e., mowing, grading, cleaning) by Delta once every five years, whereas pump stations are inspected and

maintained once a week. Storm sewer manholes are inspected annually, and storm sewers are flushed once every three years.

The Drainage and Irrigation Services Agreement, dated April 2009 (valid for 5 years; may be subject to revision or update in the future), contains several relevant considerations. Excerpts from this document are as follows:

> *6.3. Upgrades*
>
> *"… TFN will be responsible for the full cost of new drainage infrastructure that is required to accommodate development on TFN Lands. Conversely, if Delta requests that the drainage system be changed or altered because of development in Delta, the costs will be borne by Delta. Cost sharing for upgrades will consider the 6 hour, 1 day and 7 day flow and volume increases for a 1:25 year return period."*
>
> *9. Development*
>
> *"TFN will ensure that the development does not interfere with the connectivity of Delta's irrigation system. This could require that TFN move the drainage ditches if it plans to develop over existing infrastructure. Flow ditch cross-sections (conveyance capacity) from locations A, B, C, D, and E will be maintained. Ditch system configuration could be changed on consultation and cooperation with Delta Engineering. However, a similar capacity must be retained.*
>
> *All applications to connect to watercourses or to infill culverts will be made to TFN. TFN and Delta will review the application. Delta will install culvert but at full cost to TFN."*

Figure 2.1 identifies locations A through E mentioned in the excerpt above.

Dike Maintenance Agreement

TFN and Delta also have a Dike Maintenance Agreement in place, dated April 2009 (valid for 5 years; may be subject to revision or update in the future), which outlines maintenance responsibilities for the dike system (sea dike and breakwater dike) on TFN lands. The agreement recognizes that TFN's and Delta's dike systems are interconnected and it is in the best interests of both parties to maintain both dike systems to the same standard. TFN currently retains Delta to provide maintenance services on TFN dikes. The costs of repairing any deficiencies identified by Delta on TFN dikes are borne by TFN.

2.1.3 Metro Vancouver

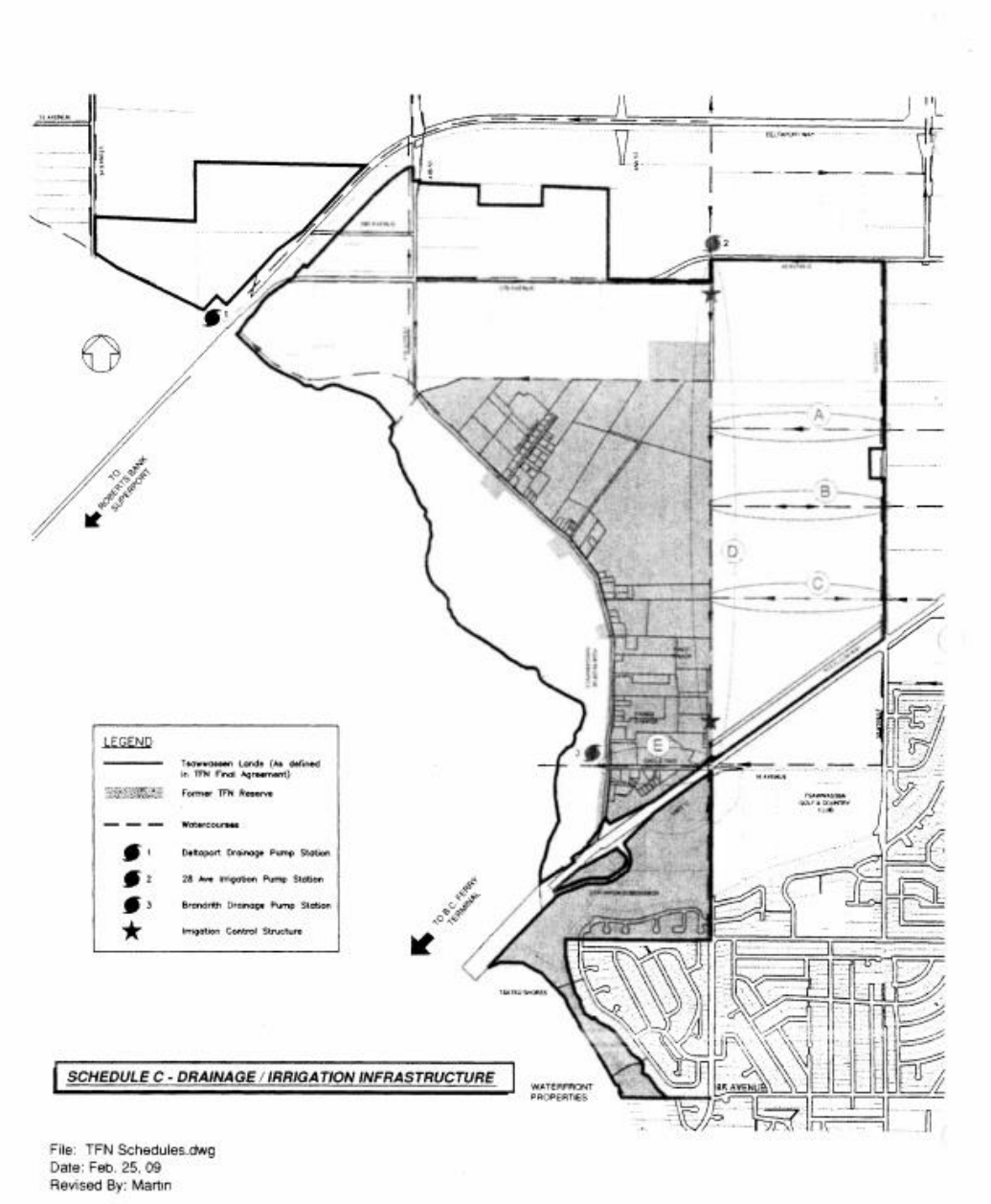
TFN became a member of Metro Vancouver, which encompasses the Greater Vancouver Regional District (GVRD), Greater Vancouver Water District (GVWD), Greater Vancouver Sewerage and Drainage District (GVS&DD), and the Greater Vancouver Housing Corporation (GVHC), in April 2009. Rainwater management is addressed by Metro Vancouver through the GVS&DD. Although legislative changes are in place to enable TFN to become a member of the GVS&DD, an entry agreement has not been established to date.

If TFN becomes a member of the GVS&DD, the authorities, regulations and bylaws of the GVS&DD pertaining to rainwater management will apply to TFN, including:

- Liquid Waste Management Plan (LWMP) – see discussion below
- Sewer Use Bylaw

GVS&DD members are responsible for developing their own regulations and bylaws to address stormwater (rainwater) management.

Figure 2.1: Schedule C – Drainage / Irrigation Infrastructure
(Source: Drainage and Irrigation Services Agreement, 2009)



Integrated Liquid Waste and Resource Management Plan

I n 2001, Metro Vancouver and its members developed and adopted a *Liquid Waste Management Plan* (LWMP). The plan endorsed the view that rainwater is a resource that, when managed properly, can be utilized to protect and enhance watershed health. The LWMP outlined an approach to Integrated Stormwater (or Rainwater) Management Planning which incorporated drainage, environment, and land use planning functions within a watershed in order to address potential rainwater impacts on a community. Metro Vancouver members committed to undertake Integrated Stormwater (or Rainwater) Management Plans (ISMP / IRMP) for all urban and semi-urban watersheds by 2014.

A *Template for Integrated Stormwater Management Plans* (TISMP) was developed in 2002 (and revised in 2005) to assist members in undertaking ISMP / IRMPs. The TISMP is not intended to be prescriptive, however, it is expected that members will draw from sections of the TISMP as it pertains to their local context. A more recent Metro Vancouver document, entitled "Integrated Stormwater Management Plans – Lessons learned to 2011" summarizes the experiences and lessons learned by members who have undertaken ISMP/IRMPs to date, and is intended to provide guidance to members completing future ISMP/IRMPs.

A new *Integrated Liquid Waste and Resource Management Plan* (ILWRMP) was developed and adopted by Metro Vancouver and its members in 2010, and subsequently approved by the Province in June 2011. Valid for eight years, the ILWRMP establishes the framework for moving beyond regulatory compliance to transitioning Metro Vancouver to an approach that achieves the Sustainable Region Vision. The three key goals of the ILWRMP are as follows:

- To protect public health and the environment
- To use liquid waste as a resource
- To ensure effective, affordable and collaborative management

The ILWRMP identifies what the region and its members intend to do to use liquid waste as a resource, minimize treatment costs and better protect the environment and public health. It also reaffirms the commitment of members to undertake ISMP / IRMPs by 2014 and requires that members implement these plans. The Minister of Environment has offered a conditional extension to 2016 for completion of the remaining ISMP / IRMPs.

If TFN becomes a member of the GVS&DD, TFN will be responsible for identifying its goals, strategies and actions with respect to the ILWRMP, including its commitment to complete and implement an ISMP / IRMP. This IRMP would satisfy TFN's requirements to complete an ISMP/IRMP, as outlined in the ILWRMP.

Regional Growth Strategy

The GVRD's Regional Growth Strategy (RGS) articulates local governments' role in watershed planning and the development of ISMP / IRMPs. The overall objectives outlined in the RGS are generally focused on guiding future land use in sustainable and environmentally responsible ways. The RGS was adopted in August 2011.

The RGS outlines five high level goals:

Goal 1: Create a Compact Urban Area

Goal 2: Support a Sustainable Economy

Goal 3: Protect the Environment and Respond to Climate Change Impacts

Goal 4: Develop Complete Communities

Goal 5: Support Sustainable Transportation Choices

Pursuant to Section 19 of Chapter 17 of the Tsawwassen First Nation Final Agreement, TFN's Land Use Plan, which was submitted to Metro Vancouver, was deemed to meet the statutory requirements of Metro Vancouver's Regional Growth Strategy

2.1.4 Provincial

Several Provincial statutes, regulations, and policies may have an influence on the IRMP, including:

- Agricultural Land Commission Act
- Dike Maintenance Act
- Drainage, Ditch and Dike Act
- Drinking Water Protection Act
- Environment and Land Use Act
- Environmental Assessment Act
- Environmental Management Act (and Waste Discharge Regulation)

- Fish Protection Act (and Riparian Areas Regulation)
- Fisheries Act
- Integrated Pest Management Act
- Water Act (and Water Regulation, Groundwater Protection Regulation)
- Water Protection Act

The Province has also published the following manuals and guidelines:

- Stormwater Planning: A Guidebook for British Columbia (2002)
- Beyond the Guidebook 2010: Implementing a New Culture for Urban Watershed Protection and Restoration in British Columbia (2010)
- Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use – Draft Policy Discussion Paper (2011)
- Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use – Sea Dike Guidelines (2011)
- Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use – Guidelines for Management of Coastal Flood Hazard Land Use (2011)
- Develop with Care 2012: Environmental Guidelines for Urban and Rural Land Development in British Columbia (2012)
- Cost of Adaptation – Sea Dikes & Alternative Strategies, Final Report (2012)
- Sea Level Rise Adaptation Primer (2013)

2.1.5 Federal

The Federal Government has passed various statutes that may be relevant to watershed health and stormwater (rainwater) management, including:

- Fisheries Act
- Canada Water Act
- Pest Products Control Act
- Canadian Environmental Protection Act
- Species at Risk Act
- Canada Wildlife Act
- Canada Marine Act

The Federal Government has also established draft development guidelines to protect fish: “Urban Stormwater Guidelines and Best Management Practices for Protection of Fish and Fish Habitat”.

2.2 Land Use

2.2.1 Existing Land Use

A significant portion of TFN lands are currently undeveloped or used for agricultural purposes. Most of the housing and community facilities (including the administration office, longhouse, church, cemetery and recreation centre) are located along Tsawwassen Drive north of Highway 17A. Commercial uses are concentrated near 48 Street and Highway 17A; these include Splashdown Park and a park-and-ride lot for BC Ferry passengers. At present there are no industrial uses on the TFN lands; however, construction in support of the proposed Phase 1 Industrial Lands near 27B Avenue and 41B Street was completed in 2011, and preloading of select sites is underway.

Much of the lowland area in Delta is currently used for agricultural purposes. However, the southern portion of the Study Area within Delta is primarily made up of residential uses, including single family homes and urban residential-type uses. The Tsawwassen Golf & Country Club and Beach Grove Golf Club are also located in this area. 56 Street serves as a commercial corridor along which restaurants, stores, a community centre and vehicle repair shops (among other uses) are located. At present, there are no industrial uses within the portion of the Study Area in Delta. A map showing the existing land uses in the IRMP Study Area is provided in Figure 2.2.

The Agricultural Land Use Inventory, a joint project between the BC Ministry of Agriculture and Metro Vancouver, was undertaken in 2010. The Ministry's Sustainable Agriculture Management Branch produced maps that indicate the crop types cultivated on Delta and TFN lands in 2010. The Delta map (Figure 2.3) shows that the majority of agricultural lands within the Study Area were used for either cultivating vegetables, pasture lands (forage) or for vines and berries in 2010. A smaller percentage of the land is currently used for producing grains, cereals and/or oilseeds. The TFN Map (Figure 2.4) shows that the majority of agricultural lands surveyed were used for growing vegetables, with other areas being used

for cultivating grains, cereals and/or oilseeds. Only a small percentage of the TFN lands were used as forage or pasture areas in 2010; however, since that time the amount of land that is no longer actively farmed has significantly increased.

The Delta Irrigation Enhancement Project (DIEP; 2010), completed as part of the South Fraser Perimeter Road (SFPR) Agricultural Enhancement Strategy, also examined crop type and distribution in the Delta area (excluding TFN lands). This study produced a similar crop type and distribution map as shown on Figure 2.3, and indicated that blueberries were the predominate berry type grown in the Study Area in 2010.

The DIEP study estimated that approximately 45% of the crops in the Study Area were irrigated in 2010 and that irrigation demands may increase in the future (up to 75%) to reflect future trends towards higher value crops that have a higher irrigation demand.

2.2.2 Future Land Use

Significant land use changes are anticipated within TFN, and to a lesser extent within Delta, in the future. There are a number of plans in place to guide future growth and development in the Study Area, including:

- TFN Land Use Plan (2009)
- TFN Enterprise Area Neighbourhood Plan (2011)
- TFN Zoning Regulation (2013)
- TFN Industrial Lands Master Plan (2009)
- TFN Tsawwassen Mills Mall and Power Centre Conceptual Site Plan (April 2011[1])
- Delta Official Community Plan (OCP) (1985; consolidated 2011)
- Delta Tsawwassen Area Plan (Schedule D.1 of Delta OCP)
- Delta Tsawwassen Springs Master Plan (2011)

Anticipated future land uses are shown on Figure 2.5.

[1] A Development Permit Application is currently under review by TFN (November 2013).

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Legend

Existing Land Use

- Agricultural
- Commercial
- Golf Course
- Institutional
- Residential
- Parks & Open Space
- TFN Cemetary
- Utility
- Tsawwassen First Nation (TFN) lands
- IRMP Study Area

Note: Orthophoto on west half of figure was taken on July 31, 2013.
Orthophoto on east half of figure was taken in 2008.

URBAN systems

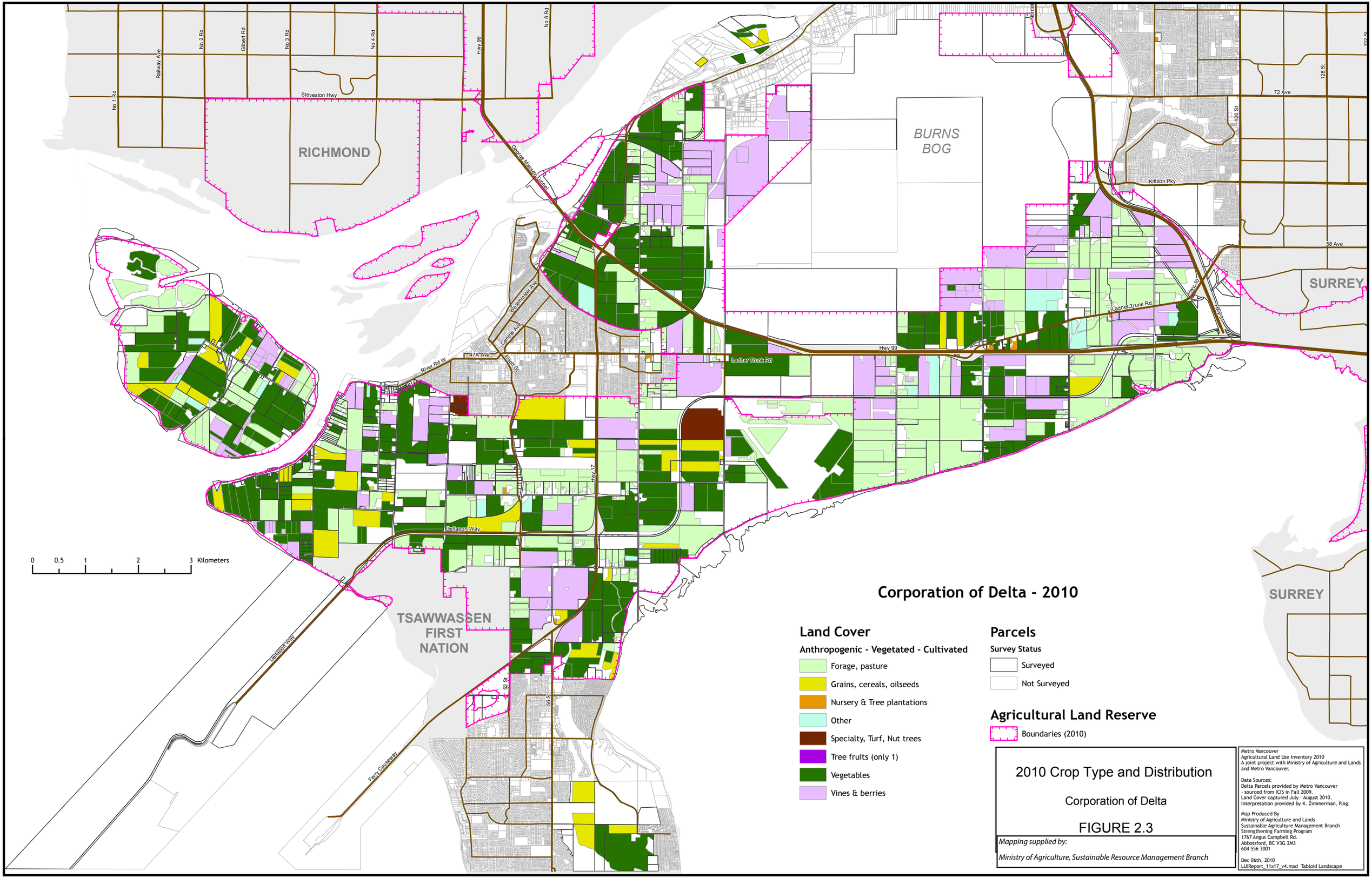
Integrated Rainwater Management Plan

Existing Land Use

Figure 2.2

0 250 500 1,000
Meters

U:\Projects_VAN\2177\0040\01\D-Drafting-Design-Analysis\GIS\Projects\MXD\Current\ModelUpdate_November2013\Figure 2.2 - Existing Land Use.mxd Last revised by: bpauls on 18/12/2013 at 3:06:45 PM



Corporation of Delta - 2010

Land Cover

Anthropogenic - Vegetated - Cultivated

- Forage, pasture
- Grains, cereals, oilseeds
- Nursery & Tree plantations
- Other
- Specialty, Turf, Nut trees
- Tree fruits (only 1)
- Vegetables
- Vines & berries

Parcels

Survey Status

- Surveyed
- Not Surveyed

Agricultural Land Reserve

- Boundaries (2010)

2010 Crop Type and Distribution

Corporation of Delta

FIGURE 2.3

Mapping supplied by:

Ministry of Agriculture, Sustainable Resource Management Branch

Metro Vancouver
Agricultural Land Use Inventory 2010
A joint project with Ministry of Agriculture and Lands and Metro Vancouver.

Data Sources:
Delta Parcels provided by Metro Vancouver - sourced from ICIS in Fall 2009.
Land Cover captured July - August 2010.
Interpretation provided by K. Zimmerman, P.Ag.

Map Produced By
Ministry of Agriculture and Lands
Sustainable Agriculture Management Branch
Strengthening Farming Program
1767 Angus Campbell Rd.
Abbotsford, BC V3G 2M3
604 556 3001

Dec 06th, 2010
LUIReport_11x17_v4.mxd Tabloid Landscape

Tsawwassen First Nation
Agricultural Land Use Inventory
2010

Deltaport Way

52 St

Ferry Causeway

Parcels

Survey Status

- Surveyed
- Not Surveyed

Agricultural Land Reserve

- Boundaries (2010)

Land Cover

Anthropogenic - Vegetated - Cultivated

- Forage, pasture
- Grains, cereals, oilseeds
- Vegetables
- Other cultivated land

0 0.5 1 Kilometers

Metro Vancouver
Agricultural Land Use Inventory 2010
A joint project with Ministry of Agriculture and Lands and Metro Vancouver.

Data Sources:
Parcels provided by Metro Vancouver
- sourced from ICIS in Fall 2009.
Land Cover captured July - August 2010.
Interpretation provided by K. Zimmerman, P.Ag.

Map Produced By
Ministry of Agriculture and Lands
Sustainable Agriculture Management Branch
Strengthening Farming Program
1767 Angus Campbell Rd.
Abbotsford, BC V3G 2M3
604 556 3001

Feb 17th, 2011
LUIReport_v1.mxd Tabloid Portrait

2010 Crop Type and Distribution

Tsawwassen First Nation

FIGURE 2.4

Mapping supplied by:

Ministry of Agriculture, Sustainable Resource Management Branch

TSAWWASSEN FIRST NATION
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Legend

Future Land Use

- Agricultural
- Commercial
- Golf Course
- Industrial
- Institutional
- Managed Forest
- Multi-Family Residential
- Parks & Open Space
- Single Family Residential
- Utility
- TFN Cemetery
- Tsawwassen First Nation (TFN) lands
- IRMP Study Area

Note: Orthophoto on west half of figure was taken on July 31, 2013.
Orthophoto on east half of figure was taken in 2008.

URBAN systems

Integrated Rainwater Management Plan

Future Land Use

Figure 2.5

0 250 500 1,000
Meters

U:\Projects_VAN\2177\0040\01\D-Drafting-Design-Analysis\GIS\Projects\MXD\Current\ModelUpdate_November2013\Figure 2.5 - Future Land Use.mxd Last revised by: bpauls on 18/12/2013 at 3:07:56 PM

Tsawwassen First Nation

The scale and impact of the following proposed developments are of most significance in terms of rainwater management:

- ***Enterprise Area Neighbourhood*** – Lands bounded by the Enterprise Area Neighbourhood Plan (approximately 110 ha in total) currently consist of low density single-family residential, along with parks and open space, and limited commercial and agricultural uses. The plan calls for significant intensification of single family and multi-family residential development and the urbanization of currently undeveloped areas. The Enterprise Area Neighbourhood is anticipated to be fully built out by the Year 2041.

- ***Tsawwassen Mills Mall and Power Centre*** – TFN's Land Use Plan identified a core commercial node near the southeast limit of TFN lands, which was to include specialty retail, mixed use, business park and hotel / tourism uses (this area is presently used for agricultural purposes). Two large scale commercial developments proposed for this area, known as the Tsawwassen Mills Mall and the Power Centre, have a conceptual site footprint greater than the amount of land designated for commercial uses in the TFN Land Use Plan (approximately 48 ha and 23 ha, respectively). The scale and intensity of the proposed land use is also more significant than originally envisioned in the Land Use Plan. Ultimate build out of the Tsawwassen Mills Mall and the Power Centre is currently anticipated by the Year 2016.

- ***Industrial Lands*** – TFN lands designated for industrial development (approximately 125 ha) are presently undeveloped or being used for agricultural purposes. The industrial lands area is anticipated to be fully built out by the Year 2041.

- ***Community Lands*** – The existing TFN community lands (approximately 48 ha) are anticipated to be redeveloped over time to a mixed use consisting of single family residential, parks, administration centers, TFN recreational facilities and cultural facilities. Approximately 270 residential units are proposed by the Year 2041.

The land use changes described above will affect the hydrologic and hydraulic behavior of TFN lands through changes to the extent and distribution of impervious and pervious areas; changes to hydraulic connectivity and loss of storage capacity due to infilling and/or relocating existing open channels; and increase in runoff generation and conveyance efficiency through improved surface grading and loss of natural surface depression storage areas.

Corporation of Delta

The Tsawwassen Springs development is the only major land use change proposed within the Study Area in Delta. This master planned community, shown on Figure 2.5, will include an expansion / relocation of the existing golf course (complete in 2013) along with condominiums, houses and related amenity facilities. This development will have some impact on hydrologic / hydraulic performance; however, much of the site will remain pervious (e.g., the golf course).

Limited redevelopment is also anticipated along the 56 Street corridor south of Highway 17A, as shown on Figure 2.5. However, these changes are not anticipated to impact hydrologic / hydraulic performance, as this area is already highly developed.

Impervious Area Computation

To better understand the potential impact of future development in the Study Area on rainwater management, the amount of impervious area within both TFN and Delta lands was calculated for existing (based on 2008 aerial photography) and future (based on the proposed development plans noted above) conditions. Impervious areas include roofs, driveways, roads, sidewalks, parking lots, and any other hard surface areas that generate rainwater runoff and do not allow for the natural infiltration of precipitation. Results are shown in Tables 2.2 and 2.3 below.

Table 2.2: Impervious Area Computation (TFN)

LAND USE	EXISTING CONDITIONS			FUTURE CONDITIONS			CHANGE IN IMPERVIOUS AREA (HA)
	Total Area (ha)	Impervious Area (ha)	Impervious Area (%)	Total Area (ha)	Impervious Area (ha)	Impervious Area (%)	
Residential	42.9	9.5	22%	116.2	53.9	46%	44.4 ha (increase)
Utility	0.4	0.4	100%	0.5	0.1	20%	0.3 ha (decrease)
Commercial	14.0	6.4	46%	77.2	74.4	96%	68.0 ha (increase)
Institutional	2.0	0.8	40%	3.0	1.7	57%	0.9 ha (increase)
Agricultural	406.9	3.0	0.7%	118.9	1.4	1.2%	1.6 ha (decrease)
Park & Open Space / Managed Forest	174.9	2.5	1.4%	181.4	7.5	4.1%	5.0 ha (increase)
Road Rights of Way	20.7	8.2	40%	46.3	33.1	71%	24.9 ha (increase)
TFN Cemetery	0.2	0.0	0%	0.2	0.0	0%	Unchanged
Industrial	0.0	0.0	0%	118.3	118.3	100%	118.3 ha (increase)
Total	662.0	30.8	4.7%	662.0	290.4	44%	259.6 ha (increase)

Table 2.3: Impervious Area Computation (Delta)

LAND USE	EXISTING CONDITIONS			FUTURE CONDITIONS			CHANGE IN IMPERVIOUS AREA (HA)
	Total Area (ha)	Impervious Area (ha)	Impervious Area (%)	Total Area (ha)	Impervious Area (ha)	Impervious Area (%)	
Residential	120.8	43.1	36%	131.5	51.0	39%	7.9 ha (increase)
Utility	2.3	1.3	57%	0.0	0.0	0%	1.3 ha (decrease)
Commercial	5.1	4.0	78%	5.1	3.9	76%	0.1 ha (decrease)
Institutional	11.3	5.5	49%	12.9	5.9	46%	0.4 ha (increase)
Agricultural	706.0	18.4	2.6%	679.8	13.8	2.0%	4.6 ha (decrease)
Parks & Open Space	62.6	1.1	1.8%	40.5	0.7	1.7%	0.4 ha (decrease)
Road Rights of Way	108.7	49.5	46%	136.6	59.3	43%	9.8 ha (increase)
Golf Course	37.2	1.4	3.8%	47.6	8.5	18%	7.1 ha (increase)
Total	1,054.0	124.3	12%	1,054.0	143.1	14%	18.8 ha (increase)

The tables above suggest that TFN will experience an increase in impervious area in the order of 260 ha under future conditions, whereas Delta will only experience an increase of approximately 19 ha.

2.3 Existing Systems Inventory

2.3.1 Drainage Infrastructure

Conveyance Network

The drainage conveyance network within the lowland portions of TFN lands primarily consists of interconnected ditches, with culverts at road and driveway crossings. The conveyance network collects and conveys rainwater and irrigation runoff to the Brandrith drainage pump station (at Tsawwassen Drive North and Eagle Way), the Deltaport drainage pump station (at Tsawwassen Road and Deltaport Way) or to existing ditches north of the Study Area. In general, ditches are linear with a minimal profile slope, and are situated parallel to roads or property lines. A similar conveyance network exists within the lowland portions of the Study Area in Delta.

In the upland portions of the Study Area (both TFN and Delta), the conveyance network generally consists of an underground storm sewer system, with limited segments of roadside ditching.

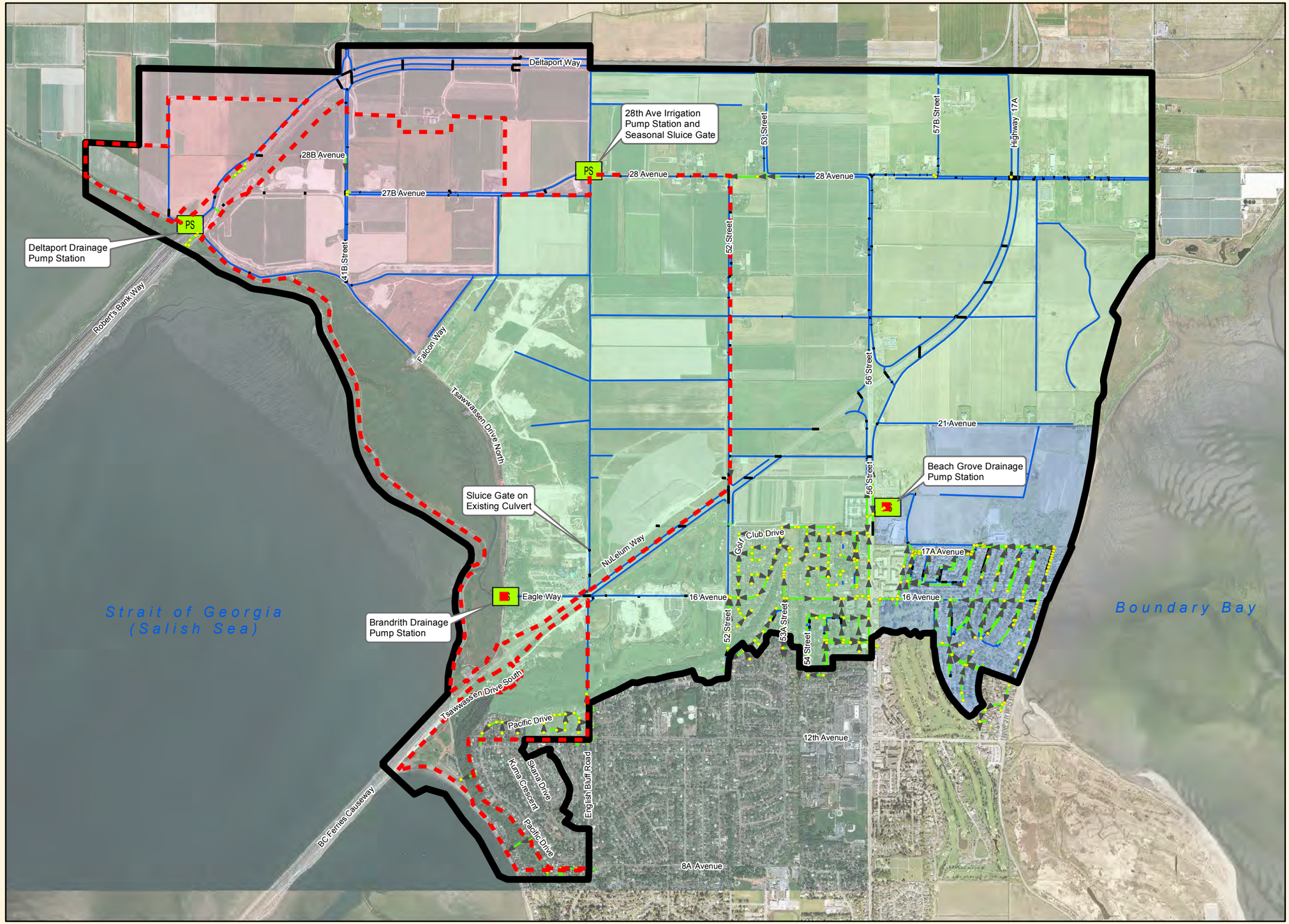
The existing drainage conveyance network is shown in Figure 2.6.

Pump Stations

Three drainage pump stations and one irrigation pump station are situated within the Study Area, as shown on Figure 2.6.

The Beach Grove pump station, located on 56 Street and 19 Avenue, receives runoff generated by areas east of 56 Street and discharges to the Brandrith pump station catchment via a trunk 1200mmØ storm sewer to the existing ditch on 52 Street. This flow, along with runoff generated by a significant portion of the Study Area, is conveyed by the ditch network to the Brandrith pump station.

The Brandrith pump station is the largest pump station in the Study Area, and has been in place since at least 1985. The station currently has two pumps with a total capacity of 2.8 m^3/s, plus a jockey pump with 0.3 m^3/s capacity. Two 1.5m wide x 1.2m high floodboxes allow flows to discharge via gravity during low tide conditions. According to Delta staff, sand bars often form in the channel immediately downstream of the station (likely due to sand being carried in during high tide, which is then deposited as the tide retreats). This downstream constriction affects the ability of the floodboxes to drain during low tide, and leads to more frequent pump operation and higher water levels in the upstream drainage network.



TSAWWASSEN FIRST NATION
sc̓əwaθən məsteyəxʷ

Legend

- Drainage Manhole
- PS — Drainage Pump Station
- Drainage Pump Station with Flood Box
- Drainage Pipe
- Culvert
- Primary Ditches
- Beach Grove Pump Station Catchment
- Brandrith Pump Station Catchment
- Deltaport Pump Station Catchment
- Tsawwassen First Nation (TFN) lands
- IRMP Study Area

Note: Orthophoto on west half of figure was taken on July 31, 2013.
Orthophoto on east half of figure was taken in 2008.

URBAN systems

Integrated Rainwater Management Plan

Existing Drainage Infrastructure

Figure 2.6

0 250 500 1,000
Meters

U:\Projects_VAN\2177\0040\01\D-Drafting-Design-Analysis\GIS\Projects\MXD\Current\First Report Figures\Figure 3 - Existing Drainage Infrastructure.mxd Last revised by: bpauls on 28/02/2011 at 10:23:53 AM

Runoff generated by the northwestern portion of the Study Area is discharged by the Deltaport pump station, which has a capacity of 0.16 m^3/s. This pump station does not have a floodbox so can only discharge flows to the ocean via the pump. According to Delta staff, the pumping capacity at this station can be overwhelmed during larger rain events, leading to localized flooding in the area.

The 28 Avenue irrigation pump station supplements water in the ditch network during the summer to provide irrigation water for agricultural purposes. Delta staff adjust the operating levels at this pump station as needed to move water from the north into the Study Area to meet irrigation demand. The station was previously supplied by a water intake on the Fraser River in Ladner (Delta), however as part of the DIEP project a new water intake was recently constructed further upstream on the Fraser River (near 80th Street) to supply water with lower saline content to the greater Delta agricultural area. Pump station catchment areas are shown on Figure 2.6.

Flood Protection

TFN lands are currently protected from flooding by a dike system along the Strait of Georgia. A single sea dike is present along the northern portion of TFN lands, while the southern portion of TFN has both a breakwater dike and a sea dike. Tsawwassen Drive North is situated on top of the sea dike along the southern reach of the dike system.

The TFN Flood Risk and Consequence Study (2010) concluded that the existing dike system is estimated to provide a near 200 year level of protection for the community. However, there was diminishing freeboard (i.e., depth related to factor of safety) present in the system where the dike was less than 3.5 metres in elevation. The report also indicated that Tsawwassen Drive North (sea dike) has been raised to minimum 2.9m elevation, which represents the current 200 year high water level in the Strait of Georgia. However, a review of the LiDAR imagery from 2009 suggests that portions of the road may still be below this elevation, as shown on Figure 2.7.

A more recent study (Delcan; 2012) commissioned by the Province of BC suggests that, due to climate change impacts, flood protection infrastructure near TFN lands may need to be altered significantly in the future to provide adequate flood protection to the community. Further discussion on flood protection is provided in Section 4.6.

TSAWWASSEN FIRST NATION
sc̓əwaθən məsteyəxʷ

Legend

- Tsawwassen First Nation (TFN) lands
- IRMP Study Area
- LiDAR Survey Boundary

Elevation (m)

- < 2.5
- 2.5 - 2.9
- 2.9 - 3.5
- > 3.5

2.9m represents the current 200 year high water level in the Strait of Georgia.
3.5m represents the flood construction level (FCL) for new developments on TFN lands.

Note: Orthophoto on west half of figure was taken on July 31, 2013.
Orthophoto on east half of figure was taken in 2008.

LiDAR survey flown in 2009. Land filling may have occured in some areas since survey.
Areas outside of LiDAR boundary supplemented with 0.5m contour data.

URBAN systems

Integrated Rainwater Management Plan

Existing Topography

Figure 2.7

0 250 500 1,000
Meters

U:\Projects_VAN\2177\0040\01\D-Drafting-Design-Analysis\GIS\Projects\MXD\Current\First Report Figures\Figure 7 - Topography.mxd Last revised by: bpauls on 28/02/2011 at 10:53:45 AM

2.3.2 Aquatic and Foreshore

Freshwater System

A detailed environmental investigation was conducted in January 2011 for the IRMP. The environmental report is provided in Appendix C.

In general, ditches in the Study Area are channelized and straight, have poor water quality characteristics, contain no characteristic features of salmonid-bearing stream habitat, and largely function as drainage structures for the surrounding agricultural lands and road system. Cohilukthan Slough is the only historical watercourse in the area and it has been substantially altered from its original condition to form land suitable for agricultural use. This slough does not connect to tidewater at its former location, further reducing its capacity to function as aquatic habitat.

Ditches within TFN lands have been classified using a combination of potential food and nutrient value, temporal nature, channel width, wetted area and flow observations. As shown on Figure 2.8, ditches were classified either as "A" or "B", defined as follows:

Ditch Class A – Remains wetted throughout the year with substantial volumes of water flow during rain events. These ditches are expected to provide moderate food and nutrient value to downstream environments, and have an average channel width around 3.5 metres and an average wetted width of around 1.8 metres.

Ditch Class B – Are wetted seasonally and experience dry periods with no substantial flows, and are often stagnant and non-refreshed. These ditches are expected to provide poor quality food and nutrient value to downstream environments, may be overgrown with vegetation or may be partially infilled. These ditches typically have a channel width less than 3.5 metres and an average wetted width less than 1.8 metres.

Both classes of instream ditch habitat are of limited value as fish habitat. The Corporation of Delta has documented brassy minnow, redside shiner, threespine stickleback and common carp within the ditch network on TFN lands. Delta also identified peamouth chub, brown catfish, and longnose sucker within the Study Area but outside of the ditch network on TFN lands. Given the connectivity of the ditches in the Study Area, these species may also occur within the TFN ditch network.

Overall, the quality of fish habitat for the freshwater systems reviewed for the IRMP is considered to be low. Many of the ditches are semi-permanent or temporal in nature and not all ditches are connected to fish-bearing streams. These ditches have poor water quality characteristics and lack habitat structure for native fish species, and presently appear to not support salmonids

LEGEND

- Study Boundary
- Tsawwassen First Nation Lands
- Forested Area to be Retained
- Approximate Location of Intertidal Marsh
- Approximate Location of Eelgrass Bed
- Occurrence of Designated Species (CDC, 2011b)
- Corporation of Delta Fish and Amphibian Sampling Site
- Great Blue Heron Rookery (Observed, Jan, 2011)
- Bald Eagle Nest (Observed, Jan, 2011)
- Pump Station

Ditch Class (Golder)

- Class A (Equivalent to Class 1 in TERA)
- Class B (Equivalent to Class 2 in TERA)

Riparian Habitat Classification

- Grass <1m Wide
- Grass >1m Wide
- Shrub <1m Wide
- Shrub >1m Wide
- Tree >1m Wide
- Highway
- Major Road
- Local Road
- Railroad

Site	Fish observed	Amphibians observed
70	Carp, Three spine stickleback, brassy minnow, redside shiner	None
71	Threespine stickleback	None
72	Carp, Three spine stickleback, brassy minnow, redside shiner	None
73	Carp, Three spine stickleback, brassy minnow	Green frog
78	Threespine stickleback, brassy minnow, redside shiner	None
90	brown catfish, longnose sucker, carp, threespine stickleback, brassy minnow, redside shiner	Green frog
91	Longnose sucker, carp, threespine stickleback, redside shiner	None

Adapted from Rithaler (2003).

NOTE

Riparian Habitat Classifications within areas designated for industrial purposes were adapted from TERA Planning Ltd (2010) and augmented based on field reconnaissance conducted by Golder Associates Ltd. in January 2011.

Samples for sediment and water chemistry were collected at Pump Station 1 and 3, January 2011.

REFERENCE

Basedata obtained from Urban Systems Ltd. VPA, 2005. Rithaler, 2003.
Street data obtained from DMTI Spatial Inc.
Projection: UTM Zone 10 Datum: NAD 83

400 0 400
SCALE 1:20,000 METRES

PROJECT
TSAWWASSEN FIRST NATION
INTEGRATED STORMWATER MANAGEMENT PLAN
TSAWWASSEN, B.C.

TITLE
TFN LANDS ECOLOGICAL FEATURES

Golder Associates
Greater Vancouver Office, B.C.

PROJECT No. 10-1435-0012			PHASE No. 1000		
DESIGN	KM	24FEB11	SCALE AS SHOWN		REV. 0
GIS	MH	21APR11			
CHECK			FIGURE 2.8		
REVIEW					

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Marine System

TFN lands are bounded to the west by the marine ecosystem that comprises various parts of the Strait of Georgia (Salish Sea). The foreshore zone to the west of TFN lands is generally referred to as part of Roberts Bank and is located between Sturgeon Bank to the north (Fraser River estuary) and Boundary Bay to the east. These areas have collectively been identified as an Important Bird Area (IBA) by BirdLife, an international partnership of conservation organizations. Due to their importance as wildlife habitat, Sturgeon Bank and Boundary Bay have also been designated as Wildlife Management Areas (WMAs) by the Province of BC. The Province has proposed to also designate Roberts Bank as a WMA, which would encompass approximately 8,700 ha of intertidal and near-shore subtidal habitat adjacent to the Tsawwassen ferry terminal and Deltaport terminal.

The intertidal and marine ecosystems at Roberts Bank are composed of three general zones: intertidal marsh, tidal flats and subtidal sands/ mudflats. Figure 2.8 highlights the extents of the intertidal marsh. This marsh is relatively new and has developed since construction of the Deltaport causeway (VPA 2005). Marsh drainage patterns include the following:

- *Tidally influenced channels* – These channels are inundated daily and are characterized by intertidal flora including eelgrass and green algae;
- *Standing channels* – These channels typically do not drain completely during low tide and are dominated by filamentous algae; and,
- *Dry channels* – These channels consist of exposed soils or are dominated by saline tolerant pickleweed.

Drainage from TFN and Delta lands are discharged into the intertidal marsh via the Brandrith and Deltaport pump stations.

The tidal mudflats are located within the intertidal area west of the diking system and are dominated by eelgrass that provides habitat for a variety of marine invertebrates and fish, which are dependent on eelgrass beds for shelter, foraging and breeding habitat. These species, in turn, provide a food source for marine birds, migrating and wintering shorebirds, larger fish species, and marine mammals, and form an integral part of the larger ecosystem.

Marine fish documented in the Roberts Bank subtidal and intertidal habitats include at least 72 different species. Typically, marine fish expected immediately downstream of the discharge points from the Study Area are those that inhabit sandy/silty bottoms with eelgrass beds, such as flatfish, sculpin, stickleback, and prickleback. Marine habitat in the intertidal area is largely covered by a shallow slope that is mostly

submerged by the tidal waters, providing habitat for small euryhaline fish and acting as nursery habitat for a range of juvenile fish, including, sculpin, flounder, and salmon. Salmon species previously documented in the downstream marine habitat include juvenile pink, chum, and Chinook salmon.

A total of 16 marine mammal species have been documented in Georgia Strait, including harbour seal, river otter, sea otter, Steller sea lion, dolphin, porpoise, grey whale, humpback whale, killer whale, toothed wale and baleen whale.

2.3.3 Vegetation

The composition of vegetation communities within TFN lands has been substantially altered since settlement by non-indigenous peoples, with a resulting decrease in the diversity of native plant species. In 2011, the majority of vegetated areas within TFN lands consisted of cultivated agricultural lands with the main crops being hay, turnips and potatoes. Vegetation composition and cover within this land cover type vary seasonally as these areas are planted, harvested and tilled annually. In 2011, approximately 10% of the agricultural fields within the TFN lands were fallow (i.e., not being actively cultivated); however, this percentage has increased since that time. Vegetation in fallow fields is dominated by grasses and low growing herbaceous plants with patches of shrubs.

Stands of coniferous and deciduous trees occur on the Tsawwassen Bluff escarpment south of Highway 17A and along larger drainage ditches. A small red alder and paper birch dominated wetland exists between the toe of the escarpment and Tsawwassen Drive South.

Watercourses and associated riparian habitat have been substantially modified since settlement and development of agriculture within TFN lands. Remaining riparian habitat is of important ecological value as it provides habitat for a variety of mammal and bird species, stabilizes ditch banks, and filters runoff from agricultural fields. Vegetation cover associated with agricultural and roadside ditches within TFN lands can be characterized as grass dominated, shrub dominated or tree dominated, as illustrated on Figure 2.8.

- Grass covered riparian habitat occurs at approximately 44% of the ditches surveyed in January 2011, with the majority of this being narrow strips of less than 1 metre from ditch top of bank.
- Shrub cover type habitat occurs at approximately 46% of ditches surveyed and is characterized by a thick shrub layer dominated by a variety of native and non-native plant species, generally greater than 1 metre in width from top of bank.

- Tree cover type habitat occurs at only 10% of ditches surveyed and varies from moderately open to closed crown cover, with most being greater than 5 metres in width from top of bank.

Further information is provided in Appendix C.

2.3.4 Wildlife

TFN lands provide habitat for a variety of wildlife species including those associated with marine, intertidal, grassland, riparian and forest habitat types. Observed and previously documented wildlife sightings of interest are shown on Figures 2.9 and 2.10. Generalized wildlife occurrences on TFN lands and adjacent foreshore and marine habitats are summarized below.

Amphibian habitat consists primarily of ditch habitat along roadways and between fields, and wetland habitat at the toe of the Tsawwassen Bluff escarpment. Previously documented amphibians include native species such as Pacific chorus frog, long-toed salamander and northwestern salamander, as well as the invasive green frog and American bullfrog, which are highly injurious to native amphibian populations. Amphibians require aquatic habitat such as ponds, wetlands, ditches, sloughs and slow moving streams for egg laying and tadpole rearing. The ditches in the area provide ample breeding habitat for most of these species.

Three species of garter snake (northwestern garter snake, common garter snake, western terrestrial garter snake) are the only reptile species that occur in the area. These species occupy edges of fallow fields, hedgerows, grass strips, riparian areas, and the upper zone of intertidal marsh habitat, where prey is abundant.

TFN lands and adjacent farmland and foreshore have been identified as an Important Bird Area (IBA) due, in part, to its role as a stop-over location along the Pacific Flyway. Approximately 264 bird species have been documented within the Boundary Bay – Roberts Bank – Sturgeon Bank IBA. They include

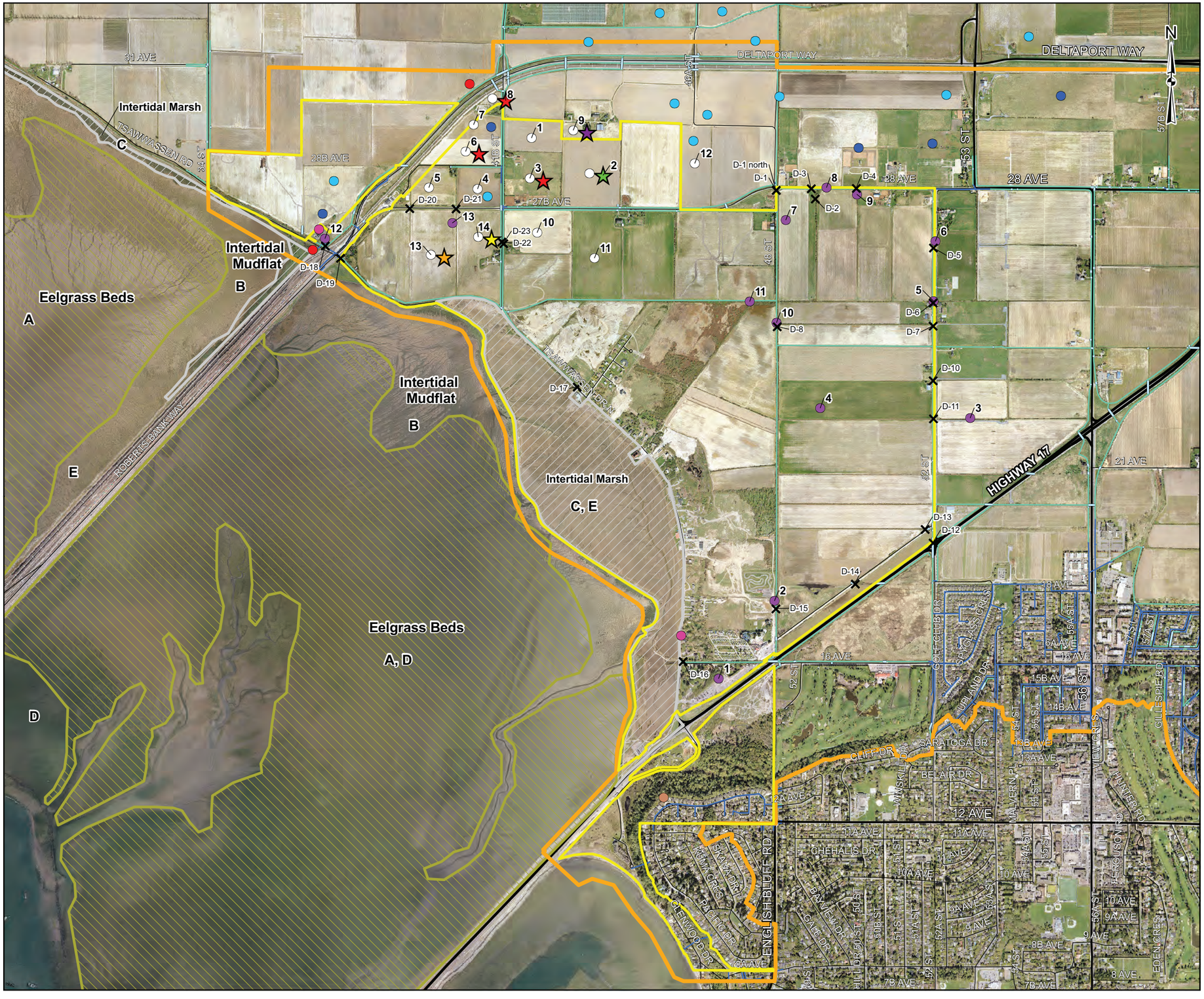
marine birds (gulls, cormorant, tern, grebe, loon, murre, murrelet, auklet, pelican, and jaeger); waterfowl (ducks, geese, swans); shorebirds (western sandpiper, dunlin, black-bellied plover); marsh birds (sora, great blue heron); raptors (owls, eagles, hawks, falcons); and other birds (songbirds, woodpeckers).

The near shore marine habitat west of TFN lands provides important foraging and overwintering habitat for marine and marsh birds. The foreshore ecosystem, including eelgrass beds, mudflats, and marsh habitat, provides shelter and foraging habitat to a variety of waterfowl and shorebird species, particularly during migration and in winter. Cultivated and fallow fields within the Study Area also provide important foraging and overwintering habitat for waterfowl species. Great blue heron frequently forage on amphibians in ditches and on small mammals alongside riparian habitat, while raptors forage over cultivated and fallow fields, ditch edges and intertidal marsh habitat. Bald eagles nest along the Tsawwassen Bluffs escarpment and throughout much of Delta, and forage over the farmlands and shoreline throughout the year. One bald eagle nest was observed during the January 2011 IRMP field work. A great blue heron colony is located in the uplands of the Tsawwassen Bluffs escarpment.

The Study Area supports small mammals (field mice, voles, shrews), aquatic furbearers (beaver, muskrat, river otter) and small carnivores and omnivores (coyote, raccoon). Vegetated leave strips between agricultural fields and along ditches provide important habitat for small mammals and connectivity between adjacent habitats. Evidence of beaver activity was observed in the ditch upstream of the Brandrith pump station while river otter use the upper shoreline to forage for fish and amphibians.

Ditches and unmaintained riparian habitat within the Study Area also provide important habitat for invertebrate species (dragonfly, aquatic insects, and butterflies). Aquatic insects and larvae provide a food source to amphibians, fish, semi-aquatic mammals and birds.

Further information is provided in Appendix C.



LEGEND

- Observed by Golder, Jan 2011
- Documented by TERA Planning Ltd., 2010
- Waterfowl Concentrations 100-500 (VPA, 2005)
- Waterfoul Concrentration >500 (VPA, 2005)
- Great blue heron Rookery (Observed, Jan, 2011)
- Eagle Nest (Observed by Golder, Jan 2011; VPA, 2005)
- Red-tailed hawk Nest (VPA, 2005)
- Approximately 500 black-bellied plovers (TERA, 2010)
- In Excess 100 white-crowned sparrows (TERA, 2010)
- In Excess of 100 European starlings (TERA, 2010)
- In Excess of 100 red-winged blackbirds (TERA, 2010)
- In Excess of 500 black-bellied plover, 1000 Dunlin (TERA, 2010)
- Ditch Photo Reference Label
- StudyBoundary
- Tsawwassen First Nation Lands
- Approximate Location of Intertidal Marsh
- Approximate Location of Eelgrass Bed
- Culverts
- Drainage_Mains
- Ditches
- Highway
- Major Road
- Local Road
- Railroad

A-Important foraging site for dabbling and diving ducks.
B-Important habitat for western sandpiper, dunlin and black-bellied plover.
C-Foraging and roosting habitat for dabbling ducks.
D-Foraging habitat for piscivorous diving birds.
E-Important habitat for semipalmated plover, killdeer and other shorebirds.

NOTE

Please refer to Figure 2b for additional infromation on Environmental Features from Golder and TERA Planning Ltd.

REFERENCE

Basedata obtained from Urban Systems Ltd., TERA, 2010, VPA, 2005.
Street data obtained from DMTI Spatial Inc.
Projection: UTM Zone 10 Datum: NAD 83

400 0 400
SCALE 1:20,000 METRES

PROJECT
TSAWWASSEN FIRST NATION
INTEGRATED STORMWATER MANAGEMENT PLAN
TSAWWASSEN, B.C.

TITLE
BACKGROUND ENVIRONMENTAL FEATURES

Golder Associates
Greater Vancouver Office, B.C.

PROJECT No. 10-1435-0012			PHASE No. 1000		
DESIGN	KM	24FEB11	SCALE AS SHOWN		REV. 0
GIS	MH	24FEB11	FIGURE 2.9		
CHECK					
REVIEW					

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Adapted from TERA Planning Ltd., 2010

English Name	Latin Name	Field Label												
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
mallard	*Anas platyrhynchos*	X	X												
ring-necked pheasant	*Phasianus colchicus*		X		X		X								
great blue heron	*Ardea herodias*	X		X		X	X		X						
bald eagle	*Haliaeetus leucocephalus*									X					
northern harrier	*Circus cyaneus*	X		X											X
Cooper's hawk	*Accipiter cooperii*	X							X						
red-tailed hawk	*Buteo jamaicensis*														X
rough-legged hawk	*Buteo lagopus*		X												
black-bellied plover	*Pluvialis squatarola*													X	X
killdeer	*Charadrius vociferus*					X	X								
dunlin	*Calidris alpina*													X	X
downy woodpecker	*Picoides pubescens*			X											
northern flicker	*Colaptes auratus*	X	X												
northwestern crow	*Corvus caurinus*	X													
black-capped chickadee	*Poecile atricapillus*					X	X		X		X				
Bewick's wren	*Thryomanes bewickii*								X						
winter wren	*Troglodytes troglodytes*								X		X				
marsh wren	*Cistothorus palustris*					X									
golden-crowned kinglet	*Regulus satrapa*			X		X			X						
American robin	*Turdus migratorius*						X		X		X				
European starling	*Sturnus vulgaris*	X		X				X		X	X				
American pipit	*Anthus rubescens*		X												
orange-crowned warbler	*Oreothlypis celata*						X								
spotted towhee	*Pipilo maculatus*		X	X		X			X	X	X				
savannah sparrow	*Passerculus sandwichensis*	X	X	X		X	X	X							
fox sparrow	*Passerella iliaca*			X	X	X			X		X				
song sparrow	*Melospiza melodia*	X	X	X	X	X	X	X	X	X	X				
Lincoln's sparrow	*Melospiza lincolnii*	X	X			X			X		X				
white-crowned sparrow	*Zonotrichia leucophrys*	X	X	X	X	X		X	X		X				
golden-crowned sparrow	*Zonotrichia atricapilla*		X	X	X	X		X			X				
dark-eyed junco	*Junco hyemalis*	X		X		X	X			X	X				
red-winged blackbird	*Agelaius phoeniceus*			X		X	X	X	X						X
western meadowlark	*Sturnella neglecta*	X	X	X				X							
Brewer's blackbird	*Euphagus cyanocephalus*			X				X	X	X					
house finch	*Carpodacus mexicanus*	X	X	X		X			X		X				
American goldfinch	*Spinus tristis*			X											
house sparrow	*Passer domesticus*	X		X		X			X						

Recorded by Golder during January, 2011 Field Surveys

English Name	Latin Name	Field Label												
		1	2	3	4	5	6	7	8	9	10	11	12	13
American robin	*Turdus migratorius*		X									X		
American wigeon	*Anas americana*							X						
bald eagle	*Haliaeetus leucocephalus*	x								X	X			
black-capped chickadee	*Poecile atricapillus*		X			X								
black-headed grosbeak	*Pheucticus melanocephalus*											X		
Cooper's hawk	*Accipiter cooperii*												X	
dark-eyed junco	*Junco hyemalis*	x												
European starling	*Sturnus vulgaris*						X						X	
great blue heron	*Ardea herodias*			X						X			X	
green-winged teal	*Anas crecca*	x						X						
house finch	*Carpodacus mexicanus*					X								
mallard	*Anas platyrhynchos*							X						
northern flicker	*Colaptes auratus*	x										X		
northern harrier	*Circus cyaneus*		X			X			X					
ruby-crowned kinglet	*Regulus calendula*	x										X		
red-tailed hawk	*Buteo jamaicensis*						X			X				
red-winged blackbird	*Agelaius phoeniceus*					X								
short-eared owl	*Asio flammeus*													X
song sparrow	*Melospiza melodia*											X		
spotted towhee	*Pipilo maculatus*										X			
trumpeter swan	*Cygnus buccinator*				X									
white-crowned sparrow	*Zonotrichia leucophrys*					X	X							
Beaver	*Castor canadensis*	X												

LEGEND

REFERENCE

400 0 400

SCALE 1:20,000 METRES

PROJECT
TSAWWASSEN FIRST NATION
INTEGRATED STORMWATER MANAGEMENT PLAN
TSAWWASSEN, B.C.

TITLE
BACKGROUND ENVIRONMENTAL FEATURES TABLES

Golder Associates
Greater Vancouver Office, B.C.

PROJECT No. 10-1435-0012			PHASE No. 1000	
DESIGN	KM	24FEB11	SCALE AS SHOWN	REV. 0
GIS	MH	24FEB11		
CHECK				
REVIEW				

FIGURE 2.10

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2.3.5 Geotechnical

Within the lowland portions of the Study Area, the natural subsurface conditions are likely comprised of a surficial topsoil horizon, overlying up to about 3 metres thickness of silt to clayey silt, overlying in the order of 50 metres thickness of interlayered sand and silt layers. Some areas of the Study Area, particularly within TFN lands, have been previously filled and the quality and composition of such fill has not been characterized, although is likely highly variable.

Within the upland portions of the Study Area, the steep slopes of the Tsawwassen Bluffs are subject to a slow process of sloughing and slope regression that is expected to continue. The slope regression generally occurs in the form of shallow debris slides, but has also likely included larger rotational earth slumps in prehistoric times, and as a result of slope disturbance caused by adverse land use and development.

The soil types constituting the Tsawwassen Bluffs include a gravel and glacial till cap up to 3 metres in thickness, overlying a silty sand to about 7 to 15 metres vertical distance below the crest of the slope, overlying silty to sandy glacial till to depths beyond the toe of the bluff. Previous sloughing and regression has resulted in a layer of colluvial deposits about 2 to 3.5 m depth below the ground surface at the toe of the slope and less than approximately 1 metre thickness on the slope itself.

Surficial geology for the Study Area is shown in Figure 2.11. Soil types and corresponding drainage characteristics are shown in Figure 2.12. Further information is provided in Appendix D.

2.3.6 Groundwater and Aquifer

The BC Aquifer Classification System has identified the sediments underlying the overbank deposits in the Study Area as a lightly developed, highly vulnerable aquifer, as shown on Figure 2.13. The aquifer is

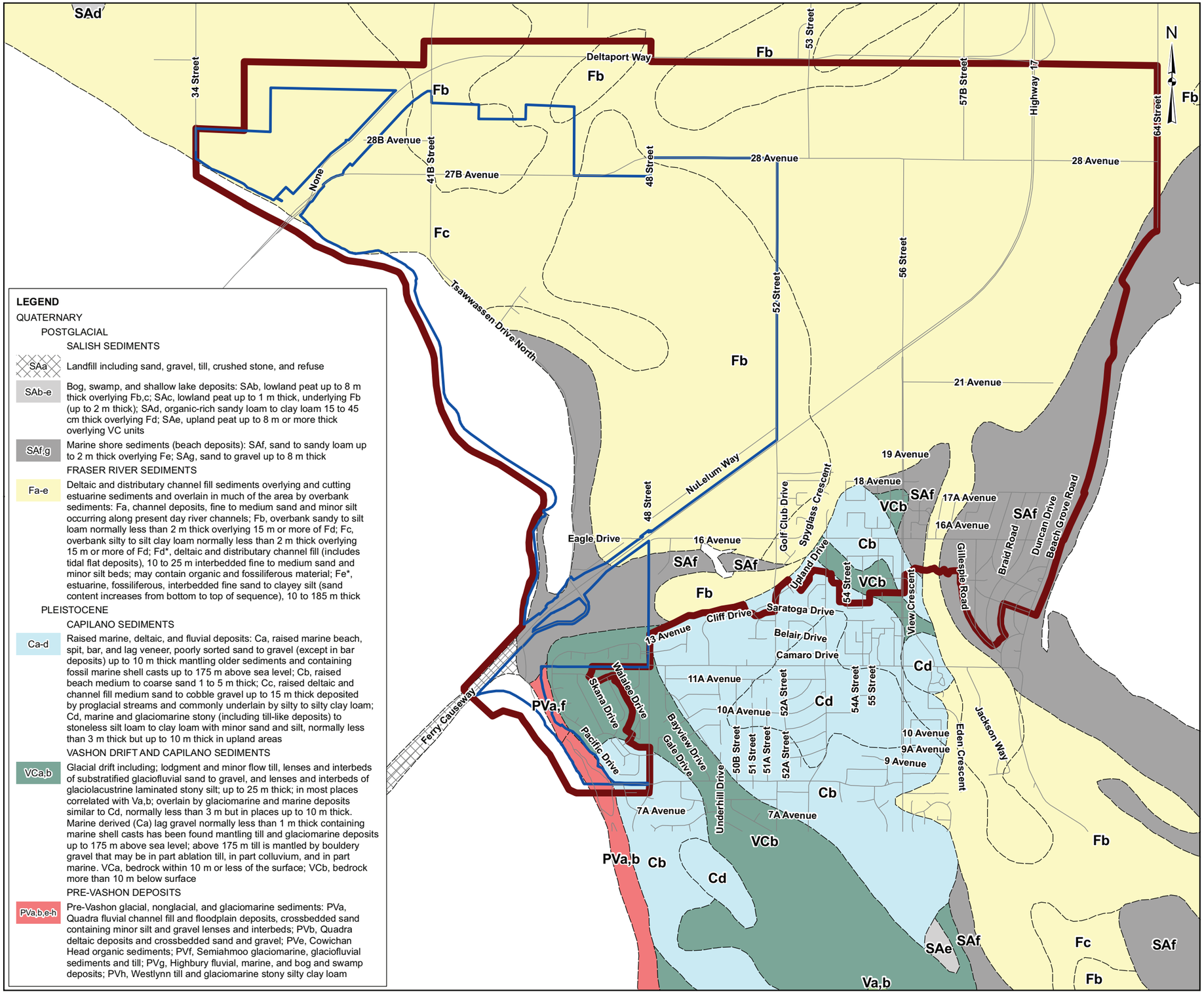
classified as moderately productive, but the type of use is described as non-drinking water purposes because of poor water quality. This means that water use within the aquifer is for industrial or irrigation purposes only. Groundwater samples previously collected from this aquifer found that the groundwater could not be used for irrigation or industrial purposes unless it was treated.

No operating domestic, irrigation or industrial water wells have been identified on TFN lands. Within the Study Area but outside of TFN lands, the three deep wells identified in the BC Water Resources Atlas all reportedly encountered brackish (or salty) water conditions and these wells have since been decommissioned. One shallow dug well was identified, but if it is still in operation it is likely that the freshwater encountered in this well is only available for part of the year.

The water table within the lowland portions of the Study Area is high and is near the surface of the natural soils during the wetter months or when irrigated. Groundwater flows downwards through the natural overbank silt to clayey silt to the underlying sand. The depth to the water level in the sand unit varies between 1 to 2 metres below the natural ground surface. Groundwater flow directions in the sand unit are complex as they are dependent on the water levels in the ditches (which are controlled by the pump stations) and the water levels in the ocean relative to the water table elevation in the sand. When the water level in the ditches or ocean (at low tide) is relatively low, groundwater flows towards the ditches and ocean. When relatively high, groundwater flows away from the ditches and ocean. The net annual groundwater flow direction is towards the ocean and ditches.

Prominent groundwater seepage occurs in the upland areas of the Study Area at the contact between the marine silty sand and the underlying glacial till layers. Zones of groundwater seepage discharge are common on the slopes at and near the slope toe of the Tsawwassen Bluffs escarpment. This contact and seepage discharge forms the initiation zones of active shallow debris slides.

Further information is provided in Appendix E.



LEGEND

QUATERNARY

POSTGLACIAL

SALISH SEDIMENTS

SAa — Landfill including sand, gravel, till, crushed stone, and refuse

SAb-e — Bog, swamp, and shallow lake deposits: SAb, lowland peat up to 8 m thick overlying Fb,c; SAc, lowland peat up to 1 m thick, underlying Fb (up to 2 m thick); SAd, organic-rich sandy loam to clay loam 15 to 45 cm thick overlying Fd; SAe, upland peat up to 8 m or more thick overlying VC units

SAf,g — Marine shore sediments (beach deposits): SAf, sand to sandy loam up to 2 m thick overlying Fe; SAg, sand to gravel up to 8 m thick

FRASER RIVER SEDIMENTS

Fa-e — Deltaic and distributary channel fill sediments overlying and cutting estuarine sediments and overlain in much of the area by overbank sediments: Fa, channel deposits, fine to medium sand and minor silt occurring along present day river channels; Fb, overbank sandy to silt loam normally less than 2 m thick overlying 15 m or more of Fd; Fc, overbank silty to silt clay loam normally less than 2 m thick overlying 15 m or more of Fd; Fd*, deltaic and distributary channel fill (includes tidal flat deposits), 10 to 25 m interbedded fine to medium sand and minor silt beds; may contain organic and fossiliferous material; Fe*, estuarine, fossiliferous, interbedded fine sand to clayey silt (sand content increases from bottom to top of sequence), 10 to 185 m thick

PLEISTOCENE

CAPILANO SEDIMENTS

Ca-d — Raised marine, deltaic, and fluvial deposits: Ca, raised marine beach, spit, bar, and lag veneer, poorly sorted sand to gravel (except in bar deposits) up to 10 m thick mantling older sediments and containing fossil marine shell casts up to 175 m above sea level; Cb, raised beach medium to coarse sand 1 to 5 m thick; Cc, raised deltaic and channel fill medium sand to cobble gravel up to 15 m thick deposited by proglacial streams and commonly underlain by silty to silty clay loam; Cd, marine and glaciomarine stony (including till-like deposits) to stoneless silt loam to clay loam with minor sand and silt, normally less than 3 m thick but up to 10 m thick in upland areas

VASHON DRIFT AND CAPILANO SEDIMENTS

VCa,b — Glacial drift including; lodgment and minor flow till, lenses and interbeds of substratified glaciofluvial sand to gravel, and lenses and interbeds of glaciolacustrine laminated stony silt; up to 25 m thick; in most places correlated with Va,b; overlain by glaciomarine and marine deposits similar to Cd, normally less than 3 m but in places up to 10 m thick. Marine derived (Ca) lag gravel normally less than 1 m thick containing marine shell casts has been found mantling till and glaciomarine deposits up to 175 m above sea level; above 175 m till is mantled by bouldery gravel that may be in part ablation till, in part colluvium, and in part marine. VCa, bedrock within 10 m or less of the surface; VCb, bedrock more than 10 m below surface

PRE-VASHON DEPOSITS

PVa,b,e-h — Pre-Vashon glacial, nonglacial, and glaciomarine sediments: PVa, Quadra fluvial channel fill and floodplain deposits, crossbedded sand containing minor silt and gravel lenses and interbeds; PVb, Quadra deltaic deposits and crossbedded sand and gravel; PVe, Cowichan Head organic sediments; PVf, Semiahmoo glaciomarine, glaciofluvial sediments and till; PVg, Highbury fluvial, marine, and bog and swamp deposits; PVh, Westlynn till and glaciomarine stony silty clay loam

LEGEND

- Tsawwassen First Nation Lands Boundary
- Study Boundary
- Roads

REFERENCE

Surficial geology obtained from the Geological Survey of Canada.
Roads obtained from DMTI Spatial Inc.
Projection: UTM Zone 10 Datum: NAD 83

500 0 500

SCALE 1:25,000 METRES

PROJECT

TSAWWASSEN FIRST NATION
INTEGRATED STORMWATER MANGEMENT PLAN
TSAWWASSEN, B.C.

TITLE

SURFICIAL GEOLOGY

Golder Associates
Greater Vancouver Office, B.C.

PROJECT No. 10-1435-0012			PHASE No. 1000		
DESIGN	DC	24FEB11	SCALE AS SHOWN		REV. 0
GIS	CDB	24FEB11	FIGURE 2.11		
CHECK	DC	01MAR11			
REVIEW	MB	01MAR11			

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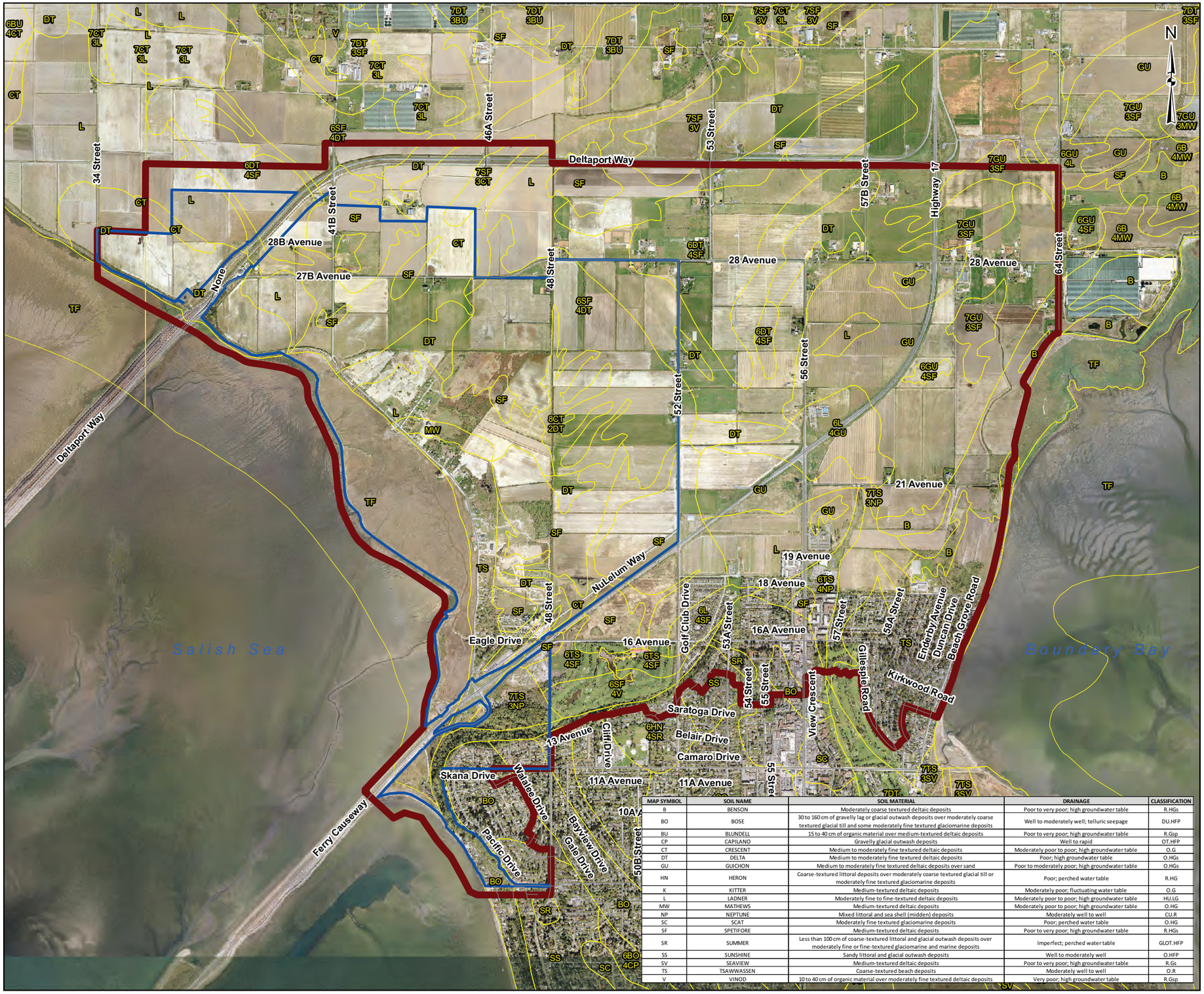

LEGEND

- Tsawwassen First Nation Lands Boundary
- Study Boundary
- Soil Polygon
- Roads

MISCELLANEOUS LAND TYPES

MAP SYMBOL	DESCRIPTION	
TF	TIDAL FLAT	Areas lying outside the dykes which are subject to flooding by tidal action

PHASES	
s	saline
sp	saline peaty

CLASSIFICATION	
CU.R	Cumulic Regosol
DU.HFP	Duric Ferro-Humic Podzol
GLOT.HFP	Gleyed Ortstein Ferro-Humic Podzol
HU.LG	Humic Luvic Gleysol
O.G	Orthic Gleysol
O.HFP	Orthic Ferro-Humic Podzol
O.HG	Orthic Humic Gleysol
O.R	Orthic Regosol
OT.HFP	Ortstein Humo-Ferric Podzol
R.G	Rego Gleysol
R.HG	Rego Humic Gleysol

MAP SYMBOL	SOIL NAME	SOIL MATERIAL	DRAINAGE	CLASSIFICATION
B	BENSON	Moderately coarse textured deltaic deposits	Poor to very poor; high groundwater table	R.HGs
BO	BOSE	30 to 160 cm of gravelly lag or glacial outwash deposits over moderately coarse textured glacial till and some moderately fine textured glaciomarine deposits	Well to moderately well; telluric seepage	DU.HFP
BU	BLUNDELL	15 to 40 cm of organic material over medium-textured deltaic deposits	Poor to very poor; high groundwater table	R.Gsp
CP	CAPILANO	Gravelly glacial outwash deposits	Well to rapid	OT.HFP
CT	CRESCENT	Medium to moderately fine textured deltaic deposits	Moderately poor to poor; high groundwater table	O.G
DT	DELTA	Medium to moderately fine textured deltaic deposits	Poor; high groundwater table	O.HGs
GU	GUICHON	Medium to moderately fine textured deltaic deposits over sand	Poor to moderately poor; high groundwater table	O.HGs
HN	HERON	Coarse-textured littoral deposits over moderately coarse textured glacial till or moderately fine textured glaciomarine deposits	Poor; perched water table	R.HG
K	KITTER	Medium-textured deltaic deposits	Moderately poor; fluctuating water table	O.G
L	LADNER	Moderately fine to fine-textured deltaic deposits	Moderately poor to poor; high groundwater table	HU.LG
MW	MATHEWS	Medium-textured deltaic deposits	Moderately poor to poor; high groundwater table	O.HG
NP	NEPTUNE	Mixed littoral and sea shell (midden) deposits	Moderately well to well	CU.R
SC	SCAT	Moderately fine textured glaciomarine deposits	Poor; perched water table	O.HG
SF	SPETIFORE	Medium-textured deltaic deposits	Poor to very poor; high groundwater table	R.HGs
SR	SUMMER	Less than 100 cm of coarse-textured littoral and glacial outwash deposits over moderately fine or fine-textured glaciomarine and marine deposits	Imperfect; perched water table	GLOT.HFP
SS	SUNSHINE	Sandy littoral and glacial outwash deposits	Well to moderately well	O.HFP
SV	SEAVIEW	Medium-textured deltaic deposits	Poor to very poor; high groundwater table	R.Gs
TS	TSAWWASSEN	Coarse-textured beach deposits	Moderately well to well	O.R
V	VINOD	10 to 40 cm of organic material over moderately fine textured deltaic deposits	Very poor; high groundwater table	R.Gsp

REFERENCE

CAPAMP soil polygons obtained from the BC Ministry of Environment.
Orthophotos obtained from Urban Systems.
Projection: UTM Zone 10 Datum: NAD 83

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SCALE 1:25,000 METRES

PROJECT
TSAWWASSEN FIRST NATION
INTEGRATED STORMWATER MANAGEMENT PLAN
TSAWWASSEN, B.C.

TITLE
SOIL TYPE AND DRAINAGE CHARACTERISTICS

Golder Associates
Greater Vancouver Office, B.C.

PROJECT No. 10-1435-0012			PHASE No. 1000		
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CHECK	DC	01MAR11			
REVIEW	MB	01MAR11			

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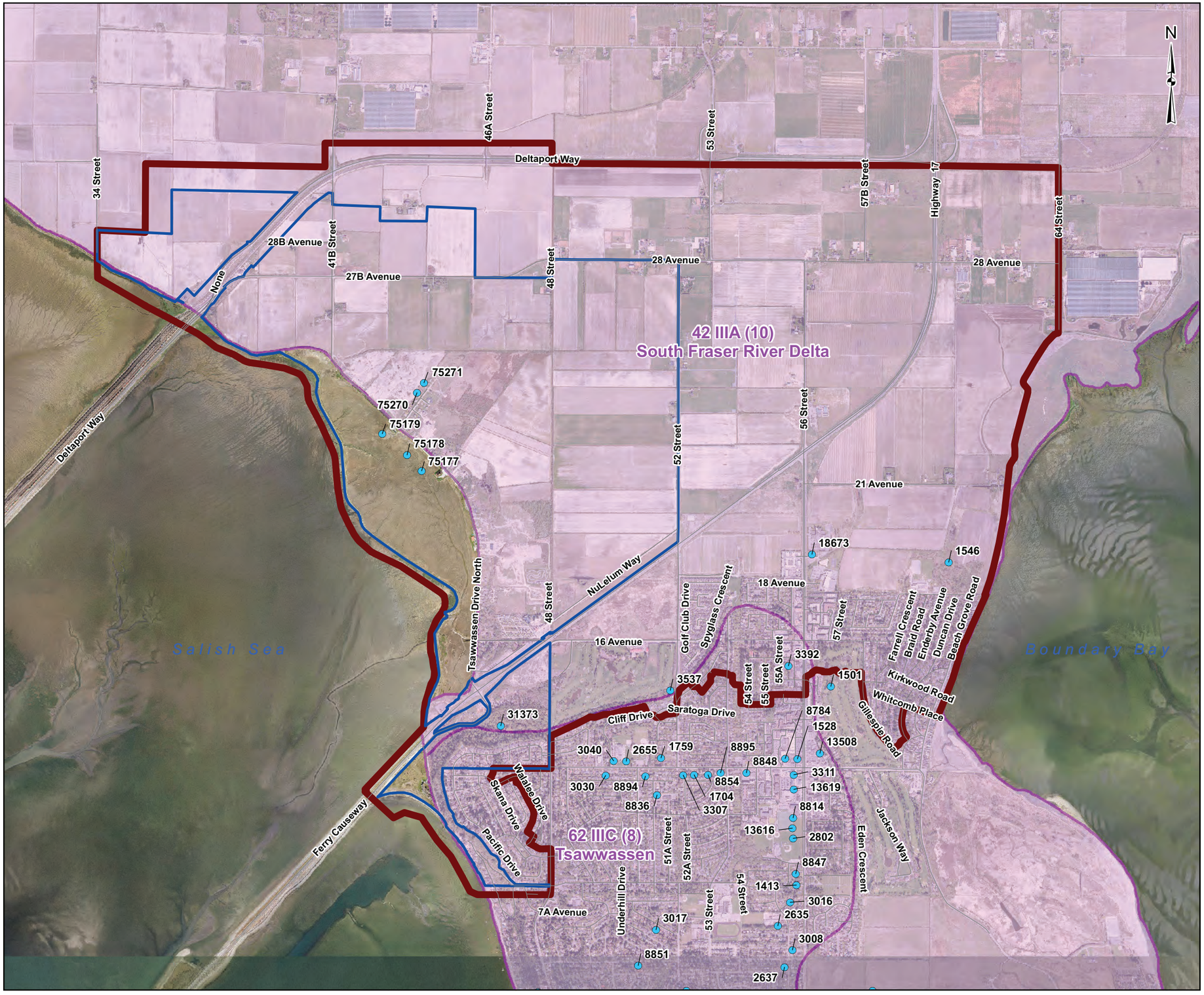

LEGEND

- Ground Water Well (labelled by well tag number)
- Tsawwassen First Nation Lands Boundary
- Study Boundary
- Aquifer
- Roads

REFERENCE

Aquifers and ground water wells obtained from the BC Land Resource Data Warehouse.
Orthophotos obtained from Urban Systems.
Projection: UTM Zone 10 Datum: NAD 83

500 0 500
SCALE 1:25,000 METRES

PROJECT
TSAWWASSEN FIRST NATION
INTEGRATED STORMWATER MANAGEMENT PLAN
TSAWWASSEN, B.C.

TITLE
AQUIFER CLASSIFICATION AND WELL LOCATIONS

Golder Associates
Greater Vancouver Office, B.C.

PROJECT No. 10-1435-0012			PHASE No. 1000	
DESIGN	DC	24FEB11	SCALE AS SHOWN	REV. 0
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REVIEW	MB	01MAR11		

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2.3.7 Water and Sediment Quality

Two sampling sites were established as part of the IRMP field investigation in January 2011; one upstream of the Brandrith drainage pump station and one upstream of the Deltaport drainage pump station. Surface water and bottom sediments were sampled and analyzed for a range of parameters.

Physical parameters measured included temperature, dissolved oxygen, pH, conductivity, turbidity, salinity, total suspended solids (TSS) and hardness. Measured levels of dissolved oxygen and TSS suggest that these parameters are limiting factors for fish in local ditches, with the lower range of dissolved oxygen measurements upstream of the Deltaport pump station being less than the minimum standards for Aquatic Life Guidelines. TSS measured at both sampling sites were above a known level of toxicity for salmonids of 7 mg/L TSS.

Although temperature was recorded at reasonable seasonal levels for aquatic life, higher temperatures could be expected during the summer months. Water temperatures in ditches limit fish distribution, as the oxygen demand increases and the ability for water to retain oxygen decreases with higher water temperatures.

Chemical and bacteriological water quality samples were also taken at both sampling sites. At the Deltaport site, measurements of iron, fluoranthene, phenanthrene, pyrene, and total coliform bacteria exceeded the BC Guidelines for Aquatic Life and Federal Water Quality Guidelines. Iron and total coliform bacteria levels also exceeded these guidelines at the Brandrith site.

Sediment samples were collected and analyzed for total organic carbon, metals, and hydrocarbon constituents. Applicable guidelines were exceeded for arsenic, chromium and copper at both sampling sites, with the Deltaport site also exceeding guidelines for cadmium and zinc. Total organic carbon and hydrocarbons levels exceeded guidelines in some instances, suggesting limitations on aquatic organisms in local ditches. Further information is provided in Appendix C.

2.4 Opportunities and Constraints

TFN's location, the surrounding natural environment and the community's connection to the land and the ocean all lend themselves to the opportunity to showcase sustainable and innovative approaches to rainwater management. TFN's Land Use Plan and Enterprise Area Neighbourhood Plan provide a supportive regulatory framework to allow the community to proceed in this direction.

Most of the existing habitat is concentrated along existing ditches and the foreshore. Future development should strive to protect and enhance these areas wherever possible, and linkages between habitat areas should be encouraged. Conversely, future development will translate into the loss of agricultural areas. Birds and other wildlife that depend on the agricultural fields for foraging and shelter may be detrimentally impacted. The creation of new environmental areas, such as the constructed wetland, managed forest and "Blue Ways" system identified in TFN's Land Use Plan, could assist in easing the impacts. Water and sediment quality in the Study Area is generally poor, and could potentially be worsened by future development. However, the conversion of agricultural lands to other land uses provides an opportunity to properly capture and treat rainwater runoff-based pollutants.

While infiltration of rainwater runoff is often considered as an approach to mitigate development impacts on the environment, infiltration of runoff in the lowland portions of the Study Area is not considered a feasible option due to the existing soil conditions and high groundwater table. Infiltration of runoff is also not recommended for the upland areas due to the risk of introducing slope instabilities on the Tsawwassen Bluffs escarpment. Therefore, the IRMP should instead focus on reducing the generation of rainwater runoff, retaining and reusing rainwater wherever possible, and properly treating runoff before it is discharged to the receiving environment.

Future development on TFN lands can provide an opportunity to meet reduction, reuse and treatment objectives by incorporating alternate road and development standards; collection, retention and reuse of rainwater for landscaping or to supplement crop irrigation demand; and proper capture and treatment of rainwater runoff-based pollutants through naturalized retention and treatment facilities.

In summary, the key issues to consider in the IRMP are:

- Water Quality
- Conveyance and Pumping
- On-Lot Rainwater Retention
- Flood Protection

3.0 What Does TFN Want?

3.1 TFN Land Use Plan – Vision and Guiding Planning Principles

TFN's Land Use Plan (2009) provides a comprehensive Vision Statement (see right) to guide future growth and development in the community. This Vision Statement was derived through extensive consultation with TFN members and is based on the three pillars of sustainability (environment, social and economic).

The IRMP can assist in realizing some of the core concepts identified in the Vision Statement, such as "*Development will not intrude on the environment, views, and idyllic location of TFN lands*" and "(*Tsawwassen Government) will deliver programs and set laws and regulations that protect and enhance the livability of the community*".

The Land Use Plan also outlines several Guiding Planning Principles that are intended to support the Vision Statement. As it relates to the IRMP, the most relevant Guiding Planning Principle is as follows:

Embrace Environmental Sustainability

The long term success of the community will be defined by its ability to achieve environmental sustainability through energy efficiency in buildings, reduced water use, stormwater management, solar orientation, on-site energy generation and innovative solutions to waste water treatment.

The Enterprise Area Neighbourhood Plan (2011) refers to and adopts the Vision Statement and Guiding Planning Principles as outlined in the Land Use Plan.

Tsawwassen First Nation Land Use Plan

Vision Statement

"In 2020, Tsawwassen First Nation will be a safe and accessible community, with infrastructure and services that make it the perfect place to raise children and to live. Our community will be close-knit, with elders and youth at the core of the community. Our people will be proud of our culture, traditions, and stories and the Hunq'um'i'num language will be enjoying a revival.

Industrial and commercial development will be active and growing, and will provide significant revenue to Tsawwassen First Nation and CP holders. However, development will not intrude on the environment, views, and idyllic location of TFN lands. Jobs will be plentiful, and businesses owned by our members will be thriving, assisted by a successful, innovative education program.

Tsawwassen Government will be responsive and transparent to our members. It will deliver programs and set laws and regulations that protect and enhance the livability of our community. Important services will be provided in the centre of the community. Our population will be growing as a result of the young population, and from members returning to live on TFN lands."

3.2 TFN IRMP – Vision for Integrated Rainwater Management

Through discussions with TFN Staff, Council and Community Members, a Vision for Integrated Rainwater Management on TFN lands has been developed.

Tsawwassen First Nation
Integrated Rainwater Management Plan
Vision Statement

Tsawwassen First Nation's (TFN) approach to Rainwater Management supports and promotes the balanced growth of the community in a way that positively contributes to the overall health of the surrounding environment. Rainwater is viewed as a resource, and development capitalizes on the opportunities to implement innovative Rainwater Management techniques while providing effective drainage service that does not impede the use and enjoyment of adjacent lands by others.

The collective Rainwater Management system allows the surrounding environment to thrive, supporting wildlife, aquatic species, and vegetation by providing habitat, food and migration routes. TFN's historic connection to the land and the sea is reflected through the proliferation of naturalized drainage systems throughout the community. Aside from their intended functions, these systems also act to educate and inform community members of the importance of Rainwater to humans and the natural environment. TFN is proud of the example that the community has set towards Rainwater Management.

3.3 Goals and Objectives

To achieve TFN's Vision for Rainwater Management, the IRMP has identified the following goals and objectives:

3.3.1 Rainwater Management

Goal # 1 – Reduce, Retain and Reuse Rainwater

For private as well as TFN-led development initiatives, opportunities to reduce the generation of rainwater runoff, to capture and retain rainwater, and to reuse rainwater to achieve complementary goals will be identified. The IRMP will outline techniques and/or processes for runoff reduction, rainwater retention and reuse of rainwater for various land use types, focusing primarily on onsite approaches that manage rainwater as close to where it falls as possible.

Goal # 2 – Provide Safe and Effective Drainage Service

The IRMP will identify conveyance, pumping and flood protection improvements that are required to support future development on TFN lands. A trunk drainage network and safe conveyance routes for extreme rainfall events will be outlined. Rights-of-way to accommodate proposed rainwater management systems will also be identified, where required. Natural, surface-oriented drainage systems will be encouraged over subsurface systems as they can support multiple goals (e.g., rainwater management, environment and landscape); however, it is recognized that an underground conveyance network may be required to effectively service some areas (and underground systems may have a smaller footprint). The rainwater management strategy will consider approaches to protect the existing TFN community from impacts of future development on adjacent lands. The strategy will also address rainwater impacts resulting from development on TFN lands, so they do not have a negative influence on the level of drainage service currently provided to the remainder of the Study Area.

Goal # 3 – Incorporate Water Quality Treatment

Water quality samples obtained during the IRMP field investigation demonstrated poor water quality (from an aquatic species perspective) within the existing drainage network on TFN lands. It is anticipated that existing water quality is also poor from an irrigation and drinking water supply perspective, given measured salinity levels. Future development provides a unique opportunity to address water quality by properly treating rainwater runoff from developed areas. The IRMP will require that future development incorporate onsite treatment of rainwater runoff prior to discharge offsite. Targeted water quality parameters will vary depending on the anticipated land use; however, natural, surface-oriented water quality treatment systems will be encouraged over engineered systems. Improved water quality will assist in achieving both rainwater management and environmental goals and objectives.

Goal # 4 – Consider Climate Change Implications

While the science regarding climate change and its potential impacts continues to evolve, trends are beginning to emerge. For TFN, the most notable climate change impact will likely be the effects of sea level rise on the community. The IRMP will consider the latest predictions for sea level rise, along with shifts in rainfall pattern distributions and land subsidence, when developing a preferred rainwater management strategy for the Study Area. Climate change implications will also inform the future flood protection improvements that may be required to service the community.

Goal # 5 – Consider Life Cycle Costs of Rainwater Management Infrastructure

The IRMP will strive to develop a rainwater management strategy that is practical, implementable and cost effective. The IRMP will itemize the drainage infrastructure works required to support future development, with consideration given to capital, operation and maintenance costs.

3.3.2 Environment

Goal # 6 – Maintain Open Channel Habitat and Functionality Where Possible

Opportunities to maintain, or ideally enhance, open channel habitat through the protection and supplementation of trees, shrubs and grass strips within riparian areas, along with invasive species removal and improved water quality, will be explored in the IRMP. Infilling existing channels will be

discouraged; however, if infilling is necessary to facilitate future development, the IRMP will highlight possible habitat compensation requirements.

Goal # 7 – Maintain Intertidal and Marine Habitat Integrity

The IRMP will identify opportunities to maintain, or ideally enhance, intertidal and marine habitat integrity by considering the inclusion of environmentally supported features as part of flood protection improvement options.

Goal # 8 – Identify Linkages to Connect Environmental Areas

Potential linkages to connect riparian areas, tree stands, green zones and the marine foreshore area will be identified (within the context of approved land use plans), with the intent of concentrating environmental assets and providing migration / movement opportunities for wildlife.

3.3.3 Geotechnical

Goal # 9 – Improve Rainwater Runoff Capture on the Tsawwassen Bluffs

The Tsawwassen Bluffs are particularly sensitive to the impacts of surface rainwater runoff and the effects of subsurface groundwater seepage on slope stability. While appreciable redevelopment is not anticipated on the Bluffs, opportunities and approaches for TFN to use to educate and inform property owners of the impacts of land use activities on runoff generation and slope stability will be explored in the IRMP.

3.3.4 Planning / Land Use

Goal # 10 – Align IRMP with TFN Planning / Study Initiatives

The IRMP will demonstrate alignment with the TFN Land Use Plan, Enterprise Area Neighbourhood Plan and Industrial Lands Master Plan, all of which have been adopted and endorsed by TFN. The IRMP will also be coordinated with TFN's Sustainability Program (in process) to promote compatibility and mutual support for both initiatives. The Bulk Water and Sanitary Trunk Master Plan (final draft) will be reviewed in tandem with the IRMP to ensure a consistent and holistic approach to water management for TFN lands.

Goal # 11 – Identify Appropriate Regulatory Framework to Guide IRMP Implementation

The IRMP will identify any necessary amendments to existing TFN regulations to guide and support the implementation of the recommended rainwater management strategy for the Study Area. New regulations may also be identified, should the current regulations not cover specific topic areas required for IRMP implementation.

Goal # 12 – Provide for Flexibility and Adaptation as Development Proceeds

It is recognized that the ultimate form, density and spatial distribution of future development may differ from that which has been assumed in the IRMP. For onsite rainwater management systems, the IRMP will identify performance targets that are based on general classes of land use rather than outlining prescriptive measures on a site-by-site basis. This approach will put onus on developers to select an appropriate suite of rainwater management solutions for their site that will achieve the intent of the

rainwater management strategy and meet or exceed TFN's standards, while allowing flexibility to address individual needs and site constraints. Further, the IRMP will identify targets and indicators, along with an adaptive management program to monitor systems as development proceeds, which will allow TFN to track whether IRMP goals and objectives are being met, and if not, what corrective actions to take.

3.3.5 Landscape

Goal #13 – Plan and Develop Landscape as a part of a Viable and Sustainable Ecological System

The character and qualities of the future landscape will reflect the environmental, social and economic vitality of development at TFN. The IRMP will provide direction towards realizing a viable and sustainable landscape that is integrated with, supported by, and supportive of natural, built and social systems. These directions will consider existing vegetation, invasive plants, habitat capacity, planting design, plant selection, and existing topsoil management, and support landscape and open space guidelines developed to date for TFN lands.

Goal #14 – Optimize the Contribution of Landscape to Rainwater Management Objectives

Water is fundamental to viable landscapes and viable landscapes can contribute significantly to reducing rainwater runoff, to retaining rainwater, and to improving water quality. The IRMP will consider landscape development at TFN as an integral component of the rainwater management strategy to use rainwater productively, to reduce concentration of surface runoff, to increase infiltration and transpiration where appropriate, to reduce erosion, and to filter, retain and treat contaminants and sediments. Topics to be reviewed may include the relationship between horticultural and hydrologic processes, water conservation, bio-conveyance, collection and infiltration, growing media requirements, mulches, and finished grading for both private and public lands.

Goal 15 – Foster a Distinctive Built Environment

The TFN lands provide a unique opportunity to establish a distinctive character for new neighbourhoods and development within the Metro Vancouver area. This character could incorporate expression of cultural traditions of TFN, reference to pre-settlement and agricultural landscapes, deliberate and intentional integration of built and natural environments, connectivity among neighbourhoods and habitats, new models for sustainable communities, and other representations of identity that are rooted at and authentic to the place. The IRMP will provide input, as appropriate, to landscape character and features, open space connectivity and "completeness", indigenous landscape, requirements for pedestrian/cycle corridors, and public and private landscape design, development and maintenance.

Goal 16 – Expand and Cultivate Understanding of Environmental, Cultural and Social Values

Landscape works at multiple levels; it is sensed, experienced, used, enjoyed, provides ecological services, forms built and natural environments, expresses cultural traditions and aesthetic intentions, and adds economic value. Landscapes can also teach and build understanding of the interactions and inter-dependencies between people and their environment. The landscape at TFN should be developed and considered in a way that contributes to greater awareness, understanding and support for the range of goals and objectives incorporated in the IRMP to encourage success and realization of benefits. To accomplish this, the IRMP will provide direction for interpretation and communication programs.

4.0 How Does TFN Put The IRMP Into Action?

4.1 Hydrologic / Hydraulic Assessment and Analysis

In support of the IRMP, a comprehensive two-dimensional hydrologic / hydraulic model was developed using the MIKE_SHE / MIKE_11 software program. The model was used to assess the hydrological characteristics of TFN lands and the overall Study Area, along with the hydraulic performance of the drainage infrastructure that services those lands under existing and future land use conditions. Details on model development, assumptions, limitations, calibration and verification are provided in Appendix F. Appendix F should be read in conjunction with the discussion below.

Models were run under the following simulations:

25 year, 24 hour – Design event used by the Corporation of Delta to size and assess the performance of trunk drainage infrastructure, including pump stations and culverts.

100 year, 24 hour – Design event used by the Corporation of Delta to assess potential impacts to properties and buildings.

ARDSA (Summer and Winter) – Agricultural and Rural Development Subsidiary Agreement (ARDSA) criteria, established by the Ministry of Agriculture to describe the level of drainage service required to support farming practices. The IRMP considered ARDSA criteria because agricultural lands are currently the dominant land use in the Study Area and the performance of drainage infrastructure servicing agricultural lands in the Lower Mainland is commonly evaluated using ARDSA criteria.

One existing servicing scenario and four future servicing scenarios were assessed for their ability to adequately service the TFN community and maintain a comparable level of drainage service to the overall Study Area. Model scenario descriptions are provided in Table 4.1.

Table 4.1: Model Scenarios

SCENARIO	LAND USE CONDITION	YEAR	CLIMATE CHANGE CONSIDERED?	PURPOSE OF SCENARIO
1	Existing	2009	No	Establish existing condition baseline for scenario comparisons
2	Future	2041	No	Size drainage infrastructure to match Scenario #1 maximum water levels to within 5% for 25 year, 24 hour event
3	Future	2041	Yes	Compare to Scenario 2; how is performance impacted if climate change does occur?
4	Future	2041	Yes	Size drainage infrastructure to match Scenario #1 maximum water levels to within 5% for 25 year, 24 hour event
5	Future	2100	Yes	Compare to Scenario 4; how is performance impacted if climate change continues to Year 2100?

The following sections summarize the modeling results and recommendations for drainage servicing improvements.

4.1.1 Existing Condition Results

Figures 4.1 through 4.4 highlight the predicted extent and depth of surface water ponding for Scenario # 1 (existing conditions), based on the model simulations described in Section 4.1.

For the 25 year, 24 hour design event (Figure 4.1), the model suggests that appreciable surface ponding occurred at the following locations within TFN lands:

- Between Tsawwassen Road and 27B Avenue (just east of Deltaport Way)
- 41B Street (north of 28B Avenue)
- Tsawwassen Drive North (north of the TFN Administration Office)[2]
- East side of 48th Street channel, north of Highway 17A
- Splashdown Park parking lot / Parks Canada RV campground
- Tsawwassen Drive South (corresponds to the existing wetland at the toe of the Tsawwassen Bluffs)

[2] TFN Advisory Council members have noted that surface ponding along Tsawwassen Drive North has occurred in the past, at the areas roughly identified by the model.

Maximum water levels in the ditches ranged from 0.74 metres to 0.78 metres immediately upstream of Brandrith and Deltaport pump stations, respectively, up to 1.0 metres on the south side of Highway 17A at 52 Street (near Snow Farm).

The model results indicate that significant areas of surface ponding are not located near the modeled ditch network, suggesting that ineffective surface grading may be responsible for much of the surface ponding issues, rather than an inadequate conveyance and pumping system. Poor soil infiltration capacity and high winter groundwater levels may also contribute to surface ponding conditions.

The model suggests that most of the culverts within TFN lands and the overall Study Area are fully submerged under a 25 year event, although water is not necessarily spilling over the ditch banks at the culvert location. Given the flat nature of the drainage system, it is acceptable to allow culverts to surcharge in order to convey the design flows, provided that head losses are not excessive and the ditch does not overtop its banks. A ditch could overtop its banks due to a culvert restriction downstream, local topography (e.g., low spot on the adjacent land), or insufficient hydraulic capacity to convey water.

Figure 4.2 highlights drainage conditions under the 100 year, 24 hour design event. The model results indicate that surface ponding occurs in the same areas identified under the 25 year, 24 hour design

TSAWWASSEN FIRST NATION
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Legend

- Modeled Culverts
- Modeled Pump Stations
- Modeled Ditch Network
- Modeled Pipe Network
- LiDAR Boundary
- Tsawwassen First Nation (TFN) lands
- IRMP Study Area

Maximum Surface Water Depth (m)

- 0 - 0.05 (not shown)
- 0.06 - 0.25
- 0.26 - 0.5
- 0.51 - 0.75
- 0.76 - 1
- > 1

(1) Topography based on LiDAR data, with expected vertical accuracy +/- 15cm.

(2) Topography based on contour data, with 0.5 meter intervals.

Note: Orthophoto on west half of figure was taken on July 31, 2013.
Orthophoto on east half of figure was taken in 2008.

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Integrated Rainwater Management Plan

Predicted Extent and Depth of Surface Water Ponding

25yr, 24hr Design Storm
Scenario 1 - Existing Condition

0 250 500 1,000
Meters

Figure 4.1

U:\Projects_VAN\2177\0040\01\D-Drafting-Design-Analysis\GIS\Projects\MXD\Current\ModelUpdate_November2013\Figure 4.1 - Extent and Depth of Surface Water Ponding - 25yr-24hr Design Storm - Scenario 1 - Existing Conditions.mxd Last updated by: bpauls on December 18, 2013 at 3:12:00 PM

TSAWWASSEN FIRST NATION
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Legend

- Modeled Culverts
- Modeled Pump Stations
- Modeled Ditch Network
- Modeled Pipe Network
- LiDAR Boundary
- Tsawwassen First Nation (TFN) lands
- IRMP Study Area

Maximum Surface Water Depth (m)

- 0 - 0.05 (not shown)
- 0.06 - 0.25
- 0.26 - 0.5
- 0.51 - 0.75
- 0.76 - 1
- > 1

(1) Topography based on LiDAR data, with expected vertical accuracy +/- 15cm.

(2) Topography based on contour data, with 0.5 meter intervals.

Note: Orthophoto on west half of figure was taken on July 31, 2013.
Orthophoto on east half of figure was taken in 2008.

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Integrated Rainwater Management Plan

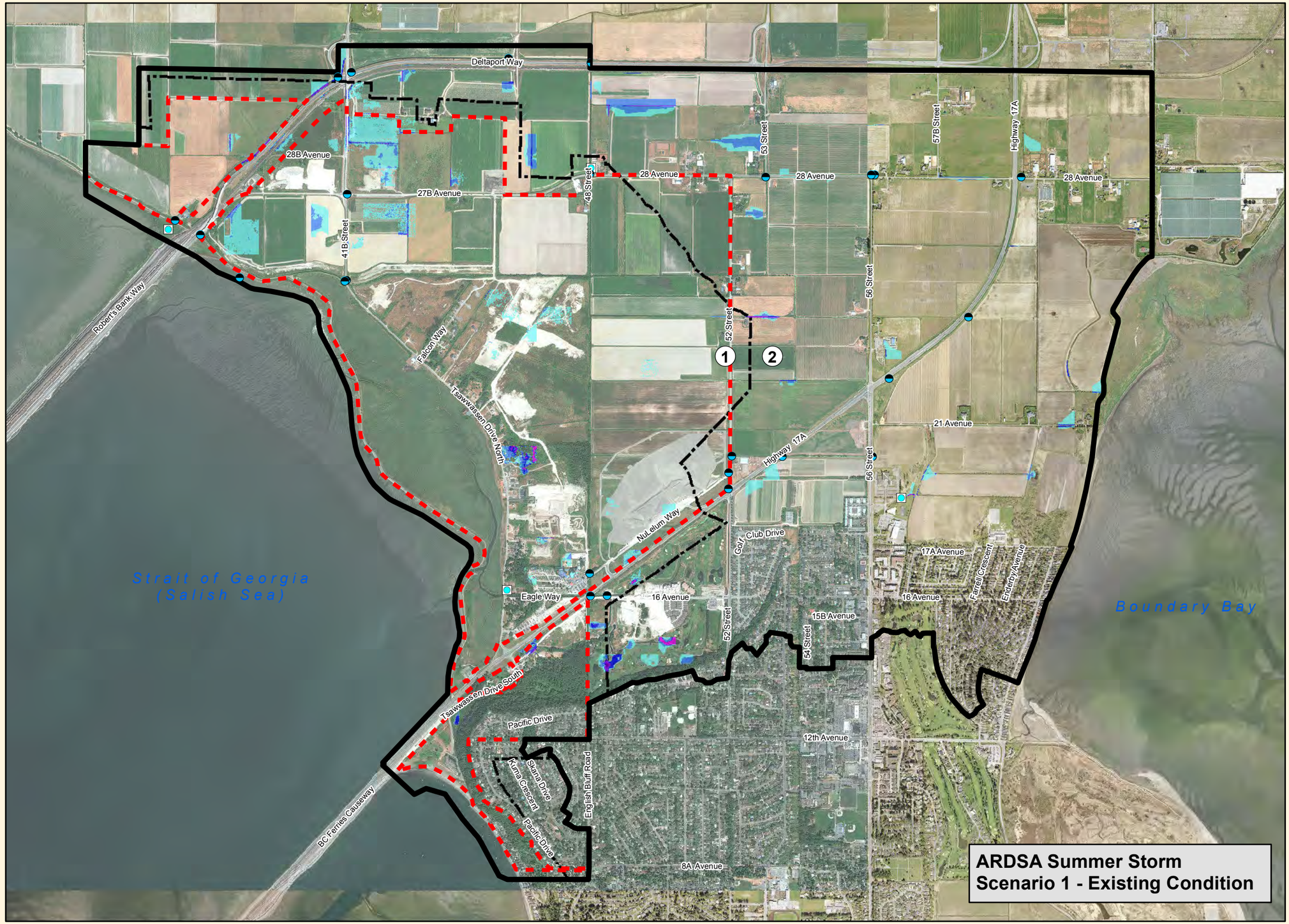
Predicted Extent and Depth of Surface Water Ponding

100yr, 24hr Design Storm
Scenario 1 - Existing Condition

Figure 4.2

0 250 500 1,000
Meters

U:\Projects_VAN\2177\0040\01\D-Drafting-Design-Analysis\GIS\Projects\MXD\Current\ModelUpdate_November2013\Figure 4.2 - Extent and Depth of Surface Water Ponding - 100yr-24hr Design Storm - Scenario 1 - Existing Conditions.mxd Last updated by: bpauls on December 18, 2013 at 3:12:56 PM



TSAWWASSEN FIRST NATION
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Legend

- Modeled Culverts
- Modeled Pump Stations
- Modeled Ditch Network
- Modeled Pipe Network
- LiDAR Boundary
- Tsawwassen First Nation (TFN) lands
- IRMP Study Area

Surface Water Depth (m)
(Remaining at the end of the10yr, 2day, ARDSA summer storm).

- 0 - 0.05 (not shown)
- 0.06 - 0.25
- 0.26 - 0.5
- 0.51 - 0.75
- 0.76 - 1
- > 1

(1) Topography based on LiDAR data, with expected vertical accuracy +/- 15cm.

(2) Topography based on contour data, with 0.5 meter intervals.

Note: Orthophoto taken in 2008.

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Integrated Rainwater Management Plan

Predicted Extent and Depth of Surface Water Ponding

Figure 4.3

0 250 500 1,000
Meters

TSAWWASSEN FIRST NATION
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Legend

- Modeled Culverts
- Modeled Pump Stations
- Modeled Ditch Network
- Modeled Pipe Network
- LiDAR Boundary
- Tsawwassen First Nation (TFN) lands
- IRMP Study Area

Surface Water Depth (m)
(Remaining at the end of the10yr, 5-day, ARDSA winter storm).

- 0 - 0.05 (not shown)
- 0.06 - 0.25
- 0.26 - 0.5
- 0.51 - 0.75
- 0.76 - 1
- > 1

(1) Topography based on LiDAR data, with expected vertical accuracy +/- 15cm.

(2) Topography based on contour data, with 0.5 meter intervals.

Note: Orthophoto on west half of figure was taken on July 31, 2013.
Orthophoto on east half of figure was taken in 2008.

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Integrated Rainwater Management Plan

Predicted Extent and Depth of Surface Water Ponding

ARDSA Winter Storm
Scenario 1 - Existing Condition

0 250 500 1,000
Meters

Figure 4.4

U:\Projects_VAN\2177\0040\01\D-Drafting-Design-Analysis\GIS\Projects\MXD\Current\ModelUpdate_November2013\Figure 4.4 - Extent and Depth of Surface Water Ponding - ARDSA Winter Storm - Scenario 1 - Existing Conditions.mxd Last updated by: bpauls on December 18, 2013 at 3:22:18 PM

event, although flooding is generally more widespread and in some instances, deeper. Within the ditch network, maximum water levels rose (up to 7 centimetres higher) at select ditch locations (see appendix F for location details). Maximum water levels in the ditches ranged from 0.79 metres (Deltaport pump station) to 1.04 metres (56 Street at Highway 17A).

Figures 4.3 and 4.4 summarize the predicted extent and depth of surface water ponding remaining at the end of the ARDSA summer storm and winter storm simulations, respectively. The model suggests that the existing drainage network generally meets the ARDSA summer storm criteria, with a few exceptions (mainly north of 28th Avenue, where ponding remains in isolated areas; these areas were also identified in the design event simulations and may be attributable to poor surface grading rather than conveyance network inefficiencies). Surface ponding remaining after the ARDSA winter storm generally coincides with the locations in the summer storm simulation, with ponding extents and depths slightly worse.

ARDSA criteria also states that, between storm events and in periods when drainage is required, base flow in channels must be maintained at 1.2 metres below field elevation. It is noted that this criteria is not met under existing conditions, according to model results, due to the operational characteristics of the pump stations (i.e., pump on/off levels are set such that the freeboard in the ditches upstream is less than 1.2 metres) and existing low field elevations adjacent to ditches in some areas.

4.1.2 Future Condition Results

Future development within TFN lands will be constructed to a flood construction level (FCL) of 3.5 metres and is assumed to have safe and effective onsite drainage conveyance systems; therefore flooding will be less of a concern in these developed areas in the future. However, due to the increased runoff from the developed areas, peak flow rates, volumes and water levels in the receiving drainage network will be higher than existing conditions unless drainage improvements are implemented. Therefore, a future conditions model was developed and utilized to identify the drainage improvements needed to mitigate future development impacts.

The following considerations were taken into account in the future conditions modeling:

Timeline Horizons

Two timeline horizons were considered as part of the future conditions analysis. The Year 2041 was selected as it represents the anticipated year for full development build-out on TFN lands, according to TFN land use plans. The Year 2100 was also reviewed as this matches the current published documentation with respect to climate change (see discussion below).

Climate Change Considerations

A recent study commissioned by the BC Ministry of Environment[3] indicates that climate change will result in a sea level rise (SLR) of 1.0 metre over existing levels for the BC South Coast by the Year 2100. This

[3] Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use – Draft Policy Discussion Paper, 2011.

is double the amount stated in previously adopted reports[4]. The 2011 report suggests that, while the actual rate of SLR is predicted to be moderate between now and 2025 then increase more rapidly between 2025 and 2100, for the purposes of assessment and analysis a constant rate for SLR should be assumed between today and 2100. Therefore, a constant rate of SLR (to 1.0 metre by the Year 2100) was incorporated in the future conditions model.

Climate change is also predicted to influence rainfall pattern distributions[5], both for total annual rainfall as well as for individual rainfall events. An annual 1-day maximum increase (17%) was applied to rainfall data for the future conditions model.

These criteria were applied to future model simulations as indicated in Table 4.1.

Land Subsidence Considerations

The 2008 report[4] also contains the latest predictions for land subsidence for the Lower Mainland. For the Fraser River / Delta area (on which TFN is situated), land is predicted to subside at a constant rate of 1 to 2 mm per year. The higher value (2 mm per year) for land subsidence was assumed in the future conditions model, for simulations where climate change was also considered.

Pump Station Requirements

Through recent discussions between TFN and Delta staff, it was concluded that TFN's Industrial Lands will be isolated from the greater drainage and irrigation network in the future. To provide adequate drainage service to TFN's Industrial Lands, a new drainage pump station will be required, with an outfall to the Strait of Georgia. The capacity requirements for this pump station were assessed as part of the future conditions modeling.

Delta staff also indicated that Delta does not wish to upgrade the Deltaport pump station or the 28th Avenue irrigation pump station, therefore the operational characteristics and pumping capacities of these pump stations were not changed for future conditions modeling.

The following sections summarize the key results of the future condition scenario models.

Scenario # 2 – Year 2041, Full Buildout, No Climate Change

The objective of Scenario # 2 was to answer the question: "What drainage improvements would be required to provide adequate service to TFN lands and the overall Study Area in the Year 2041, assuming that full buildout of TFN lands is in place and climate change (i.e., sea level rise, rainfall pattern distribution), as well as land subsidence, does not occur?"

Scenario # 2 was initially run under the 25 year, 24 hour design event and assessed for its ability to service the TFN community and maintain a comparable level of drainage service (compared to existing

[4] Projected Sea Level Changes for British Columbia in the 21st Century, 2008 (commissioned by the Government of Canada).
[5] Vulnerability of Vancouver Sewerage Area Infrastructure to Climate Change, 2008.

conditions) for the remainder of the Study Area. Pumping and conveyance improvements were implemented in the model and sized to bring future maximum water levels under the 25 year, 24 hour design event to within 5% of existing maximum water levels (per existing condition model results) at key locations of interest within the Study Area (see Appendix F for location details). Once the 5% criterion was realized at the key locations of interest, the remaining model simulations (100 year, ARDSA) were run with the drainage improvements in place to assess performance.

To meet the 5% water level criteria described above for the 25 year, 24 hour design event, the following drainage improvements were included in the future conditions model:

- Increase total capacity of existing Brandrith Pump Station from 2.8 m^3/s to 5.2 m^3/s (plus existing jockey)
- Install a new pump station to service the TFN Industrial Lands, with a capacity of 2.5 m^3/s
- Upgrade several culverts along the 48th Street and 52nd Street drainage channels to increase conveyance capacity[6]

Figure 4.5 highlights the predicted extent and depth of surface water ponding during the 25 year, 24 hour design event. When compared to Figure 4.1, the model results indicate that surface ponding extents and depths are generally the same, or in some cases improved, over existing conditions with the above noted drainage improvements in place. For example, surface ponding extents will be appreciably reduced along the east and west sides of Highway 17A (between 21st and 28th Avenues), according to the model results. Surface ponding is eliminated within future development areas on TFN lands, as the model assumes that these lands have been built to an FCL of 3.5 metres and have safe and effective onsite drainage conveyance systems.

Water levels at key points of interest in the Study Area are included in Appendix F. Based on the model results, the greatest increase in peak water levels occur in the vicinity of 48th Street and Highway 17A (approximately 4 centimetres for the 25 year, 24 hour design event). Maximum water levels in the ditches ranged from 0.76 metres immediately upstream of the pump stations to 0.97 metres on the south side of Highway 17A at 52 Street (Snow Farm).

Under the 100 year, 24 hour design event, the model indicates that maximum water levels will increase by up to 10% (or 9 centimetres) over existing conditions, with the greatest increases occurring near 48th Street and Highway 17A, and immediately upstream of the Brandrith pump station. Peak water level elevations range from 0.77 metres (Deltaport pump station) to 1.04 metres (56th Street at Highway 17A).

Figure 4.6 summarizes the predicted extent and depth of surface water ponding during the 100 year, 24 hour design event. Ponding extents are essentially the same as existing conditions; however, model results suggest that ponding depths may increase slightly near 41B Street and Deltaport Way and along the south side of Highway 17A (near the 20th Avenue alignment).

[6] Culvert upgrades were recommended to limit differential head loss through the culvert to 300mm or less.

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Legend

- Modeled Culverts
- Modeled Pump Stations
- Modeled Ditch Network
- Modeled Pipe Network
- LiDAR Boundary
- Tsawwassen First Nation (TFN) lands
- IRMP Study Area

Maximum Surface Water Depth (m)

- 0 - 0.05 (not shown)
- 0.06 - 0.25
- 0.26 - 0.5
- 0.51 - 0.75
- 0.76 - 1
- > 1

(1) Topography based on LiDAR data, with expected vertical accuracy +/- 15cm.

(2) Topography based on contour data, with 0.5 meter intervals.

Note: Orthophoto on west half of figure was taken on July 31, 2013.
Orthophoto on east half of figure was taken in 2008.

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Integrated Rainwater Management Plan

Predicted Extent and Depth of Surface Water Ponding

25yr, 24hr Design Storm
Scenario 2 - Future Condition 2041

0 250 500 1,000
Meters

Figure 4.5

U:\Projects_VAN\2177\0040\01\D-Drafting-Design-Analysis\GIS\Projects\MXD\Current\ModelUpdate_November2013\Figure 4.5 - Extent and Depth of Surface Water Ponding - 25yr-24hr Design Storm - Scenario 2 - Future Managed Conditions 2041.mxd Last updated by: bpauls on December 18, 2013 at 3:24:53 PM

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Legend

- Modeled Culverts
- Modeled Pump Stations
- Modeled Ditch Network
- Modeled Pipe Network
- LiDAR Boundary
- Tsawwassen First Nation (TFN) lands
- IRMP Study Area

Maximum Surface Water Depth (m)

- 0 - 0.05 (not shown)
- 0.06 - 0.25
- 0.26 - 0.5
- 0.51 - 0.75
- 0.76 - 1
- > 1

(1) Topography based on LiDAR data, with expected vertical accuracy +/- 15cm.

(2) Topography based on contour data, with 0.5 meter intervals.

Note: Orthophoto on west half of figure was taken on July 31, 2013.
Orthophoto on east half of figure was taken in 2008.

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Integrated Rainwater Management Plan

Predicted Extent and Depth of Surface Water Ponding

100yr, 24hr Design Storm
Scenario 2 - Future Condition 2041

0 250 500 1,000
Meters

Figure 4.6

U:\Projects_VAN\2177\0040\01\D-Drafting-Design-Analysis\GIS\Projects\MXD\Current\ModelUpdate_November2013\Figure 4.6 - Extent and Depth of Surface Water Ponding - 100yr-24hr Design Storm - Scenario 2 - Future Managed Conditions 2041.mxd Last updated by: bpauls on December 18, 2013 at 3:23:08 PM

Figures 4.7 and 4.8 summarize the model results for Scenario # 2 under the ARDSA summer and winter storms, respectively. The model results indicate that surface ponding extents and depths are essentially unchanged from existing conditions, for both simulations. Ditch water levels also decrease under both simulations compared to existing conditions (by 15 centimetres for the summer simulation, 3 centimetres for the winter simulation) due to improved pumping capacity.

In summary the model results indicate that, with the drainage improvements noted above in place, Scenario #2 can provide a comparable level of drainage service (when compared to existing conditions) for the Study Area to the Year 2041, assuming no climate change or land subsidence impacts.

Scenario # 3 – Full Buildout by Year 2041, with Climate Change

Using the Scenario # 2 model as a base, climate change impacts and land subsidence were added to develop the Scenario # 3 model. The objective of Scenario # 3 was to answer the question: "If the drainage improvements outlined in Scenario # 2 were implemented, and climate change and land subsidence does occur, to what degree would drainage infrastructure performance be impacted?"

For Scenario # 3, the predominant effect of SLR and land subsidence is the decreased performance of the pump station flood boxes, which rely on gravity discharge during low tides to release water to the ocean. This in turn results in an increased reliance on the pumps to discharge runoff. For the 25 year, 24 hour design event, the model suggests that maximum water levels will rise by up to 10% (8 centimetres) over Scenario # 2, or 14% (11 centimetres) over existing condition levels. The largest magnitude changes occur near Highway 17A and 48th Street, and immediately upstream of the Brandrith pump station.

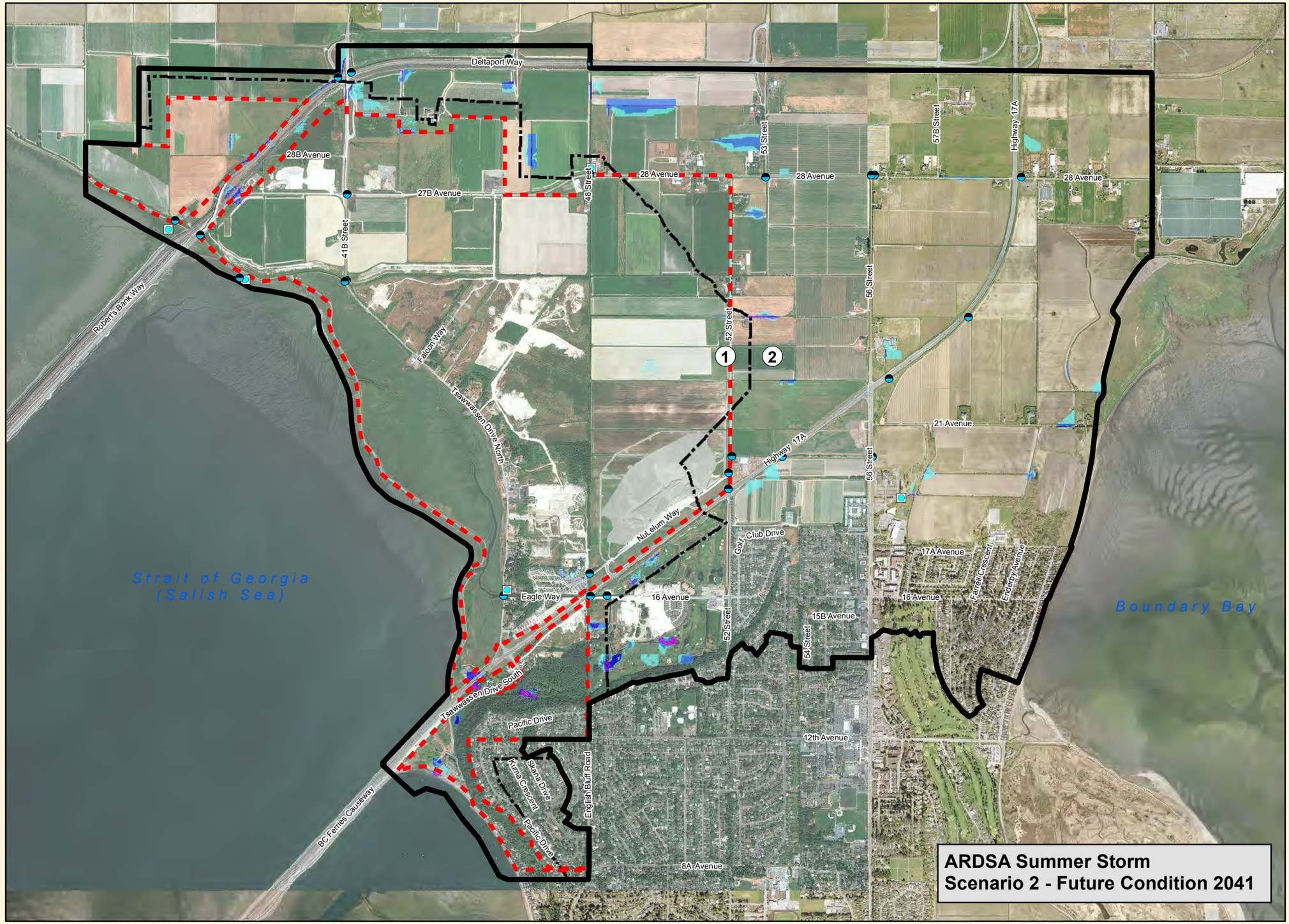
For the 100 year, 24 hour design event, model results indicate that maximum water levels will rise by up to 7% (6 centimetres) over Scenario # 2, or 16% (14 centimetres) over existing condition levels, with the most significant changes occurring near at the same locations as those identified for the 25 year, 24 hour design event.

For the ARDSA summer and winter storms, water levels are the same or lower than Scenario # 2 and existing conditions water levels at the end of the storm simulations. Appendix F provides further details on water levels for all model simulations for Scenario # 3.

The model results for Scenario # 3 indicate that future maximum water levels for the 25 year, 24 hour design event would not be within 5% of existing water levels at all points of interest in the Study Area, unless additional drainage improvements beyond those identified in Scenario # 2 were implemented. That said, the maximum predicted increase in water levels (11 centimetres for the 25 year, 24 hour design event) is fairly minimal and may not be apparent in the field.

Scenario # 4

Using the Scenario # 3 model as a base, the proposed drainage improvements were refined to bring future peak water levels to within 5% of existing peak water levels (for the 25 year, 24 hour design event) at all points of interest in the Study Area. The objective of Scenario # 4 was to answer the question: "What would the ultimate drainage improvements need to be to match future peak water levels to within



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Legend

- Modeled Culverts
- Modeled Pump Stations
- Modeled Ditch Network
- Modeled Pipe Network
- LiDAR Boundary
- Tsawwassen First Nation (TFN) lands
- IRMP Study Area

Surface Water Depth (m)
(Remaining 2 days after the 10yr, 2-day, ARDSA summer storm).

- 0 - 0.05 (not shown)
- 0.06 - 0.25
- 0.26 - 0.5
- 0.51 - 0.75
- 0.76 - 1
- > 1

(1) Topography based on LiDAR data, with expected vertical accuracy +/- 15cm.

(2) Topography based on contour data, with 0.5 meter intervals.

Note: Orthophoto on west half of figure was taken on July 31, 2013.
Orthophoto on east half of figure was taken in 2008.

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Integrated Rainwater Management Plan

Predicted Extent and Depth of Surface Water Ponding

Figure 4.7

0 250 500 1,000
Meters

U:\Projects_VAN\2177\0040\01\D-Drafting-Design-Analysis\GIS\Projects\MXD\Current\ModelUpdate_November2013\Figure 4.7 - Extent and Depth of Surface Water Ponding - ARDSA Summer Storm - Scenario 2 - Future Managed Conditions 2041.mxd Last updated by: bpauls on December 18, 2013 at 3:26:33 PM

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Legend

- Modeled Culverts
- Modeled Pump Stations
- Modeled Ditch Network
- Modeled Pipe Network
- LiDAR Boundary
- Tsawwassen First Nation (TFN) lands
- IRMP Study Area

Surface Water Depth (m)
(Remaining 2 days after the 10yr, 5-day, ARDSA winter storm).

- 0 - 0.05 (not shown)
- 0.06 - 0.25
- 0.26 - 0.5
- 0.51 - 0.75
- 0.76 - 1
- > 1

(1) Topography based on LiDAR data, with expected vertical accuracy +/- 15cm.

(2) Topography based on contour data, with 0.5 meter intervals.

Note: Orthophoto on west half of figure was taken on July 31, 2013.
Orthophoto on east half of figure was taken in 2008.

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Integrated Rainwater Management Plan

Predicted Extent and Depth of Surface Water Ponding

ARDSA Winter Storm
Scenario 2 - Future Condition 2041

Figure 4.8

0 250 500 1,000
Meters

U:\Projects_VAN\2177\0040\01\D-Drafting-Design-Analysis\GIS\Projects\MXD\Current\ModelUpdate_November2013\Figure 4.8 - Extent and Depth of Surface Water Ponding - ARDSA Winter Storm - Scenario 2 - Future Managed Conditions 2041.mxd Last updated by: bpauls on December 18, 2013 at 3:27:06 PM

5% of existing peak water levels, if climate change and land subsidence does occur as predicted between today and the Year 2041?"

In order to match future peak water levels to within 5% of existing peak water levels for the 25 year, 24 hour design event, the model results indicate that the Brandrith pump station capacity would need to be increased from 2.8 m^3/s to 7.0 m^3/s. The Industrial Lands pump station capacity and the conveyance improvements identified in Scenario # 2 would remain unchanged. With these improvements in place, the maximum water levels in the ditch network would range from 0.70 metres at the Brandrith pump station to 1.02 metres at 56th Street at Highway 17A for the 25 year, 24 hour design event, based on the model results.

For the 100 year, 24 hour design event, the model suggests that maximum future water levels would be as much as 10% (or 9 centimetres) above existing peak water levels, with the greatest increases occurring near 48th Street and Highway 17A. This is comparable to the Scenario # 2 results for this design event.

Water levels in the ditch network at the end of the ARDSA summer and winter simulations differ slightly from existing conditions, but are no more than 6 centimetres for the summer simulation and 3 centimetres for the winter simulation, based on the model results.

In summary the model results indicate that, if the Brandrith pump station capacity was increased to 7.0 m3/s, along with the implementation of the Industrial Lands pump station and culvert improvements as outlined in Scenario # 2, Scenario #4 can provide a comparable level of drainage service (when compared to existing conditions) for the Study Area to the Year 2041, with climate change and land subsidence in place.

Scenario # 5

In order to gain an understanding of the additional impacts climate change and land subsidence could have on the Study Area in the long-term, one final scenario was assessed. Using the Scenario # 4 model as a base, sea level rise and land subsidence effects were increased to reflect predicted levels for the Year 2100. Rainfall was not increased beyond the previous scenarios however, as currently published reports do not provide information on how rainfall patterns might change for this time horizon. Further, it was assumed that land uses remained constant between the Years 2041 and 2100. The objective of Scenario # 5 was to answer the question: "If the capacity of Brandrith pump station was increased to 7.0 m^3/s and sea level rise and land subsidence continues as predicted to the Year 2100, to what degree would drainage performance be impacted?

The primary effect of additional sea level rise and land subsidence on the drainage network is to further reduce the ability of the pump station floodboxes to discharge during low tide, which creates the need for increased reliance on the pumps to compensate for the decreased floodbox performance. However, for the 25 year, 24 hour design event, the model results indicate that this will have a minimal effect on future maximum water levels in the ditches (up to 1%, or 1 centimetre) when compared to Scenario # 4 results. This is due to the fact that the floodbox performance was already significantly compromised for Scenario # 4. Future peak water levels for Scenario # 5 are up to 6% (or 5 centimetres) higher than existing peak

water levels, with the largest increases occurring immediately upstream of Brandrith pump station, and 52nd Street at 24th Avenue.

For the 100 year, 24 hour design event, model results indicate that maximum water levels will rise by up to 6% (5 centimetres) over Scenario # 4, or 9% (8 centimetres) over existing condition levels, with the most significant changes occurring near 52nd Street and Highway 17A, and 48th Street and Highway 17A.

For the ARDSA summer simulation, the model results indicate that water levels are the same or lower than existing conditions except immediately upstream of the Brandrith pump station, where water levels are predicted to be up to 3 centimetres higher. For the ARDSA winter simulation, water levels fluctuate within 4 centimetres of existing water levels according to the model results.

In summary the model results indicate that, if the Brandrith pump station capacity was 7.0 m^3/s and climate change and land subsidence continues as predicted to the Year 2100, any impacts on the performance of the drainage network would be minimal, when compared to Scenario # 4 results.

4.1.3 On-Lot Retention Strategies

The scenarios analyzed above were based on understanding drainage system performance during large magnitude design events, or following multi-day ARDSA rainfall events. However, it is recognized that around 90% of the annual rainfall in the Lower Mainland occurs as part of small, frequent storm events[7]. Retention strategies can assist in reducing runoff peaks and volumes to the overall drainage network by retaining water from these small, frequent events on-lot.

One of the most effective on-lot retention strategies used in the Lower Mainland is the incorporation of a thick layer of amended topsoil in pervious areas. Amended topsoil is a manufactured soil with controlled properties such as void ratio (typically around 25%). A higher void ratio allows for increased retention and treatment of rainfall which has positive effects for frequent, low intensity storm events in addition to providing some attenuation of peak flows during infrequent, high intensity storm events. Amended topsoil has also been shown to be an effective means of replicating depression storage, which is typically lost when lands are developed; thus an approach that incorporates amended topsoil can strive to replicate this aspect of the hydrologic cycle post-development.

As an example, consider a proposed single family residential lot (small lot) on TFN lands. Using the site coverage outlined in the Enterprise Area Neighbourhood Plan for this land use type, the total lot area is estimated to be 320 m^2, of which 185 m^2 might be covered by impervious surfaces (and 135 m^2 is pervious). If 300mm of amended topsoil (with 25% void ratio) was placed within all pervious areas of this lot, the topsoil would have the potential to hold approximately 10 m^3 of rainwater runoff. A ½ MAR event would generate approximately 4.5 m^3 of runoff from the impervious areas of the lot which is less than the potential capacity of the topsoil, suggesting that ½ MAR could be fully retained on-lot.

[7] Stormwater Planning: A Guidebook for British Columbia (2002). The guidebook recommends on-lot retention of up to ½ the Mean Annual Rainfall (MAR). The MAR is a 24 hour rainfall depth defined statistically as the 1 in 2.33 year return period event. For TFN, the MAR is 48 mm (based on the DT55 Ferry Road Pump Station rain gauge); thus ½ MAR would be 24 mm.

The effectiveness of on-lot retention strategies may be reduced during winter conditions or following successive rainfall events, as soils may be near or at their saturation point and have limited ability to retain additional water. However, on an annual basis they can be effective and should be implemented as part of private developments as well as within public rights-of-way. Further, although the greatest benefit of amended topsoil is typically achieved for land uses with appreciable pervious area (e.g., parks, open space, single family lots), a consistent criteria should be adopted for all future land uses within TFN.

4.1.4 Recommended Servicing Approach

Section 4.1.2 analysed several scenarios for their ability to provide adequate drainage service to TFN lands, and maintain a comparable level of drainage service (compared to existing conditions) for the remainder of the Study Area, for future land use conditions. Section 4.1.3 outlined additional on-lot strategies that should be implemented to enhance rainwater retention.

The science around climate change continues to evolve. The analysis completed for the IRMP utilizes the best available information at the time of the study with the recognition that, as more data becomes available and the science continues to advance, climate change predictions are quite likely to change. With that in mind, the IRMP focused on ways to optimize and enhance the current drainage system in a way that would allow shorter term development to proceed (by providing incremental improvements to existing infrastructure rather than investing in major works) until development reaches a level that necessitates the need for major infrastructure investments, and/or when the actual impacts of climate change are better understood. This approach is also in line with the IRMP goal to identify cost effective, practical and implementable ways to service the community.

A review of the record drawings for the Brandrith pump station, along with discussions with a local pump supplier, indicate that the Brandrith pump station could be retrofitted to increase its capacity to 5.2 m^3/s. However, the existing structure is not of sufficient size to accommodate a 7.0 m^3/s capacity increase. Therefore, the preferred servicing scenario is Scenario # 2, as described in Section 4.1.2.

The following drainage improvements are recommended:

- Increase total capacity of Brandrith Drainage Pump Station from 2.8 m^3/s to 5.2 m^3/s (plus existing jockey) by retrofitting the existing station[8]
- Construct a new drainage pump station for the TFN Industrial Lands with a pumping capacity of 2.5 m^3/s
- Upgrade several culverts along the 48th Street and 52nd Street drainage channels to increase conveyance capacity
- Provide 300mm depth of amended topsoil in all pervious areas within new development (both private and public areas)

[8] Retrofits include upgrading the pump chamber for new tubes, access hatches and flapgates; installing new pumps with 5.2m^3/s total capacity (plus existing jockey pump); installing a new discharge line beneath Tsawwassen Drive; and miscellaneous electrical and mechanical improvements.

- Disconnect impervious areas to the greatest extent possible (e.g., discharge roof downspouts to splash pads for single family and multi-family residential development, grade sites to drain impervious areas to pervious areas)
- Maximize opportunities to decrease impervious surfaces (e.g., reduce road widths and parking areas, use porous paving materials for driveways, patios, parking pads, on-street parking areas, etc.)
- Review opportunities to retain rainwater runoff generated by impervious surfaces though the use of rainwater management features (RMFs) including rain gardens, vegetated bioswales, rainwater harvesting techniques, etc.

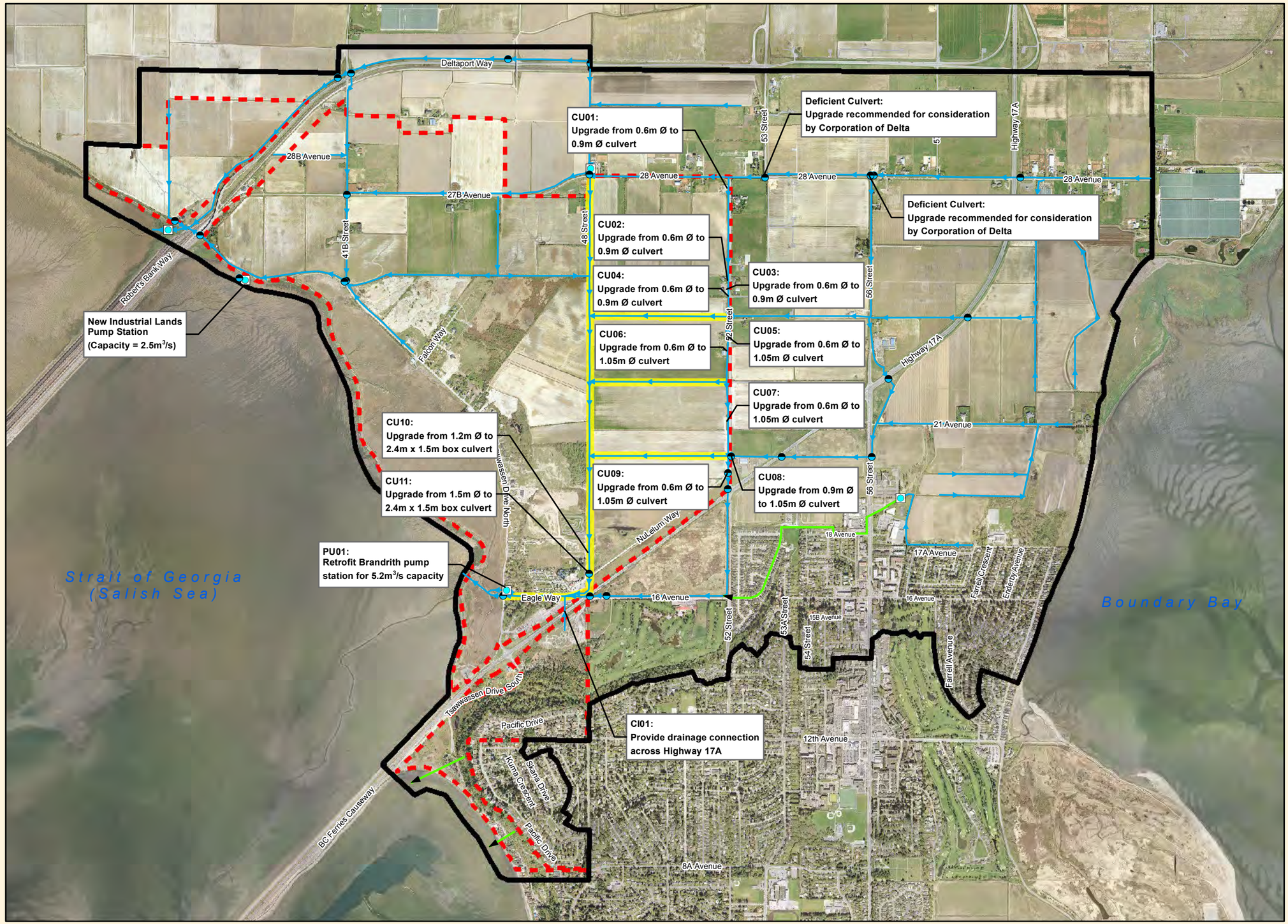
It is recognized that the Brandrith pump station does not meet current structural or seismic codes; however, it has remaining service life and it would be most cost effective to optimize the current station than to build a new station at this time. A feasibility assessment should be undertaken in support of detailed design for the pump station upgrades. The assessment should determine the remaining service life of the pump station structure, including an evaluation of its structural integrity and its anticipated performance following a seismic event (including associated risk factors should performance be significantly impacted), as well as a power source review.

As part of the IRMP adaptive management program (see Section 5.2), water levels immediately upstream and downstream of the Brandrith pump station should be monitored to assess ditch water levels and actual trends in sea level rise over time. Once service levels have degraded to a point that the larger pump station capacity (7.0 m^3/s) is required, a new pump station can be designed and constructed to the applicable structural and seismic codes, as well as climate change and land subsidence predictions of the day.

Pumping and conveyance improvements are summarized in Figure 4.9. These improvements, along with amended topsoil and water quality treatment facilities (see Section 4.2), will provide adequate drainage service to the TFN community and overall Study Area to full buildout of TFN lands by the Year 2041. Infrastructure improvements identified herein are based on best available information and may be subject to modification through review and approvals of development applications and detailed design. Designs may be accepted by TFN where general conformance with the strategy and infrastructure improvements described herein is demonstrated by the proponent to provide the same level of service as described in this IRMP.

Drainage components specifically identified in the “Drainage and Irrigation Services Agreement” between TFN and the Corporation of Delta are also highlighted on Figure 4.9. As required in the agreement, these drainage channels have been maintained in their current alignments for all future scenarios. However, as per the agreement, these alignments may be reconfigured through consultation and cooperation with Delta, provided the capacity is maintained. Additionally, all proposals to reconfigure this system would have to conform to environmental recommendations as described in Section 4.3 of this report, and be subject to environmental approvals.

Culverts that are outside of TFN lands, but noted as potentially deficient through the hydraulic analysis, are identified on Figure 4.9. The criteria used for identifying these culverts as deficient are surcharging at the inlet with differential head loss across the culvert greater than 300mm, and a potential to back up



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Legend

- Modeled Culverts
- Modeled Pump Stations
- Modeled Ditch Network
- Modeled Pipe Network
- Watercourses identified within the Drainage and Irrigation Services Agreement.
- Tsawwassen First Nation (TFN) lands
- IRMP Study Area

Note: Orthophoto on west half of figure was taken on July 31, 2013.
Orthophoto on east half of figure was taken in 2008.

URBAN systems

Integrated Rainwater Management Plan
Recommended Drainage Infrastructure Improvements

Figure 4.9

0 250 500 1,000
Meters

U:\Projects_VAN\2177\0040\01\D-Drafting-Design-Analysis\GIS\Projects\MXD\Current\ModelUpdate_November2013\Figure 4.9 - Recommended Drainage Infrastructure Improvements.mxd Last updated by: bpauls on December 18, 2013 at 3:45:15 PM

water levels or cause flooding to upstream areas. Culverts external to TFN that are identified as deficient, but which will not be further impacted by development of TFN lands, would be given consideration by the Corporation of Delta alone.

A new drainage connection has been recommended (CI01 on Figure 4.9) to service future development south of Highway 17A. As the existing culvert crossing at Highway 17A is heavily utilized during extreme storm events, it is not recommended to introduce additional flow upstream of this crossing. It is recommended that a new dedicated Highway 17A crossing be installed with direct connection to the Brandrith Channel downstream of the existing Highway 17A culvert crossing. It is expected that this installation would require trenchless technologies. The culvert size has been estimated at 1200mm diameter, but is subject to a detailed design.

The trunk drainage network for the TFN community consists of the Cohilukthan Slough, the 48th Street channel, and the Brandrith channel. Future local minor and major conveyance systems for TFN developments should be connected to this "spine" network. Internal drainage of development will be designed to direct runoff to this spine network and to mitigate impacts of runoff on adjacent lands within or external to TFN.

For design of local drainage conveyance systems within TFN, it is recommended that the following design criteria be used:

- Minor System – 10 year
- Major System – 100 year

These design criteria are complementary to the design criteria currently used by the Corporation of Delta. Drainage facilities within the Ministry of Transportation and Infrastructure (MoTI) right-of-way may require different design criteria to be utilized – MoTI design standards should be applied in this instance.

4.1.5 Cost Estimates

Construction cost estimates were prepared for the recommended pumping and conveyance improvements described above. Aside from these specific improvements, the assessment has determined that the existing channel configuration and geometry can service future development. The costs associated with system modifications proposed for other reasons (e.g., road widening, development proposals) have not been included at this time. Such costs would need to be identified and attributed to those other specific initiatives.

Cost estimates, summarized in Table 4.2, are representative of Class D cost estimates and include 35% contingency and 12% engineering, but exclude GST. Detailed cost breakdowns are provided in Appendix G.

Table 4.2: Class D Construction Cost Estimates

ITEM	TOTAL
Retrofit Brandrith Drainage Pump Station for 5.2m³/s capacity	$ 1,259,000
TFN Industrial Lands Drainage Pump Station (2.5 m³/s capacity)	$ 2,498,000
CI01: Provide drainage connection across Highway 17A (allowance)	$500,000
CU01: Upgrade existing 600mm to 900mm HDPE Culvert	$ 56,000
CU02: Upgrade existing 600mm to 900mm HDPE Culvert	$ 47,000
CU03: Upgrade existing 600mm to 900mm HDPE Culvert	$ 47,000
CU04: Upgrade existing 600mm to 900mm HDPE Culvert	$ 50,000
CU05: Upgrade existing 600mm to 1050mm HDPE Culvert	$ 46,000
CU06: Upgrade existing 600mm to 1050mm HDPE Culvert	$ 46,000
CU07: Upgrade existing 600mm to 1050mm HDPE Culvert	$ 50,000
CU08: Upgrade existing 900mm to 1050mm HDPE Culvert	$ 61,000
CU09: Upgrade existing 600mm to 1050mm HDPE Culvert	$ 102,000
CU10: Upgrade existing 1200mm to 2.4m x 1.5m Box Culvert	$ 132,000
CU11: Upgrade existing 1500mm to 2.4m x 1.5m Box Culvert	$ 147,000
Subtotal	**$ 5,041,000**
35% Contingency	$ 1,764,000
12% Engineering	$ 605,000
TOTAL	**$ 7,410,000**

Costs for amended topsoil within public rights-of way and parks are assumed to be included in the costs of those projects, therefore a cost estimate has not been provided in the above table.

Costs associated with water quality treatment and amended topsoil within private lands are anticipated to be borne directly by the development community, therefore a cost estimate has not been provided in the above table.

Works could be funded through TFN's offsite levies (OSL) program, or through a future rainwater management utility, depending on the nature of the work, the benefitting area, and TFN's preference for cost recovery.

4.2 Water Quality

4.2.1 Pollutants of Concern

There are a number of potential organic and inorganic substances found in rainwater runoff. In essence, just about anything that finds its way onto urban surfaces — particularly impervious surfaces such as roads, parking lots, and buildings — can be washed off those surfaces by rain and snowmelt. This is called "non-point source" (NPS) pollution because the sources tend to be highly dispersed across the landscape. In some cases, NPS pollution is washed directly into watercourses; in other cases it is conveyed by storm sewers. Many NPS pollutants can be acutely toxic at higher concentrations, although in general such toxicity is not normally associated with "typical" urban runoff. Rather, the accumulated effects of pollutant washoff over time can yield unacceptable chronic toxicity in watercourses and their sediments, as well as unacceptable bioaccumulation in aquatic life.

Typical pollutants that are conveyed in rainwater runoff include suspended sediments; nutrients such as nitrogen and phosphorous; trace metals such as copper, nickel and zinc; bacteria; and hydrocarbons. Many of these are by-products of vehicle use (i.e., automobiles, buses and trucks), but also of such things as the use of chemicals to maintain green lawns, chemicals in roofing and other construction materials, pet and wildlife droppings, and even general littering. Table 4.3 lists common NPS pollutants and their sources. It is assumed that many, if not all, of the pollutants listed below will be present in rainwater runoff from developed TFN lands.

Table 4.3: Common Non-Point Source Pollutants and Their Sources

POLLUTANT	COMMON SOURCES
Total Suspended Solids (TSS)	Construction sites; exposed or poorly vegetated lawns and open space; pavement wear; vehicle use, including maintenance; litter breakdown; de-icing (sand); industrial yards; atmospheric deposition
Petroleum Products (often called Oil & Grease)	Spills, leaks and blow-by of motor lubricants, antifreeze and hydraulic fluids from vehicles; industrial/commercial development sites; uncovered fueling stations; industrial yards
Nutrients (Nitrogen; Phosphorous)	Fertilizer application on lawns, golf courses and playing fields; open space; atmospheric deposition

POLLUTANT	COMMON SOURCES
Lead	Vehicle use (tire wear; lubricating oil; grease; bearing wear; batteries); paint
Zinc	Vehicle use (tire wear; motor oil stabilizing additive); galvanized pipe; uncoated metal roofs; corroding building surfaces; high use parking lots and driveways; industrial sites; de-icing (salt); wood preservatives; paint; atmospheric deposition
Copper	Vehicle use (metal plating, bearing and bushing wear; moving engine parts; brake lining wear); fungicides, insecticides and algaecides; industrial sites; paint; atmospheric deposition
Cadmium	Vehicle use (tire wear); insecticides
Chromium	Vehicle use (metal plating; moving engine parts; break lining wear); paint
Pathogens*	Livestock, pets and wildlife; lawns and open space; roofs; gutters & storm drains
Polycyclic Aromatic Hydrocarbons (PAHs)	Vehicle use (partially combusted fuels); atmospheric deposition from stationary sources (e.g., partially combusted carbon-based fuels such as wood, coal, diesel, etc.)

**Frequently identified in rainwater management studies by using either total or fecal coliform bacteria as an indicator*

To illustrate the potential effects of NPS pollutants once they have been conveyed to a watercourse, the impacts of several common NPS pollutants are briefly noted here. High levels of TSS can damage fish and aquatic invertebrates and degrade in-stream habitat where the material settles onto gravel and cobble substrates. Besides simply producing an unsightly sheen to water, petroleum hydrocarbons (as represented by oil and grease) can be directly toxic to aquatic life. Copper and Zinc are primary trace metals of concern because of their adverse impacts on fisheries. Copper interferes with fish sensory systems related to predator avoidance, juvenile growth and migratory success. Zinc alters behavior, blood and serum chemistry, impairs reproduction and reduces growth. Presence of pathogens (including viruses, bacteria and parasitic protozoa) can directly cause infections in those cases of contact recreation or other use of contaminated water, and can lead to contamination and closure of shellfish harvesting areas. PAHs are known for their carcinogenic, mutagenic and teratogenic properties; they show moderate to high acute and chronic toxicity to aquatic life.

For purposes of the IRMP, the targeted NPS pollutants are:

- Total suspended solids (TSS)
- Oil and grease (O&G)
- Trace metals; as represented by copper and zinc

Pathogens and PAHs have been found in open channels at TFN (see Stage 1 IRMP Discussion Paper) and could have been included in the list of targeted pollutants. PAHs are lipophilic, i.e., they mix easily with oils rather than water; further they are also commonly associated with soil and sediments (i.e., TSS). Thus, focusing on removal of TSS and oils will also tend to remove PAHs. Pathogens, presumed present when an indicator species such as fecal coliform bacteria are detected, are solids themselves and often associated with inorganic sediments (e.g., silts); further, exposure to sunlight and contact with organic soils tends to kill or remove fecal coliform bacteria. Thus, focusing on TSS removal as well as

emphasizing the use of "naturalized" surface oriented rainwater management systems will provide a high level of fecal coliform treatment.

In addition, because of their toxicity and carcinogenic potential, pesticides (including herbicides, fungicides and insecticides) should be targeted as well. These are best controlled through strict restrictions or complete bans on their use, rather than by attempting to remove them once entrained in runoff (see Section 4.5 for further details of a recommended cosmetic pesticide use regulation for the TFN).

Many pollutants found in rainwater runoff are to some degree hydrophobic; in other words, they are associated with sediments that can, in turn, be settled or filtered. This suggests that, once entrained in runoff, a basic treatment strategy can focus on removing total suspended solids (TSS), after which increasingly more intensive treatment can be applied to remove dissolved pollutants. That said, it is always preferable to keep pollutants out of runoff in the first place, through source controls, street cleaning, and other best management practices.

4.2.2 Performance Targets

The following overall performance targets have been established for use within TFN lands:

- **Basic Control** – Basic treatment focuses on removal of TSS along with associated pollutants attached to those sediments, including low levels of petroleum hydrocarbons (oil and grease and PAHs). Basic control is applicable to all non-agricultural lands within TFN. The performance target is:
  - 80% removal of TSS for influent event mean concentrations (EMCs[9]) greater than 100 mg/L but less than 200 mg/L; for influent EMCs less than 100 mg/L, meet a goal of 20 mg/L effluent TSS. For sites generating TSS greater than 200 mg/L, provide Enhanced Control (see below); and,
  - Treatment should be applied to a runoff volume generated by 25 mm of rainfall per hectare of impervious surface; runoff above this volume may bypass the treatment system(s); for systems requiring the use of a flow rate for design, base the computations on Table 4.2 below.
- **Oil Control –** Oil removal is specifically required for sites where there is significant likelihood that higher concentrations of petroleum hydrocarbons will be released; in general, this includes sites with significant presence or use of vehicles. The performance target is:
  - No on-going or recurring visible sheen in receiving watercourse(s), and 24-hour average Total Petroleum Hydrocarbon (TPH) concentration no greater than 10 mg/L with a maximum discrete (grab sample) concentration no greater than 15 mg/L; and,

[9] The "event mean concentration" (EMC) is the total mass of pollutant in runoff from a storm event divided by the total volume of runoff from that same storm event.

- Treatment should be applied to all runoff with no bypass allowed, and the catchment area to the treatment system may be restricted to drives, roads and parking areas.

- **Enhanced Control** – Enhanced control is intended to achieve a higher level of dissolved metals removal and applies to sites experiencing intense vehicle usage, for example, industrial sites, or other activities likely to yield higher levels of pollutants. The performance target is:
  - Exceed basic removal of TSS;
  - Greater than 50% removal of the dissolved fractions of copper and zinc; and,
  - Treatment should be applied to a runoff volume generated by 25 mm of rainfall per hectare of impervious surface; runoff above this volume may bypass the treatment system(s); for systems requiring the use of a flow rate for design, base the computations on Table 4.4.

Table 4.4: Flow Rates for Enhanced Control Treatment

Storm Duration (Time of Concentration, T_C) (hrs)	Flow Rate per Impervious Area (L/s/impervious ha)*
0.1	167.2
0.2	83.1
0.3	54.9
0.4	40.6
0.5	31.9
0.6	25.0
0.7	20.1
0.8	16.5
0.9	13.9
1.0	11.9
1.5	6.6
2.0	4.4

*Values may be interpolated (for T_C<2 hours) and extrapolated (for T_C>2 hours) on log-log plots of the data in this table.

Table 4.5 shows how these performance targets will be applied to the various land uses anticipated within TFN. As well, the table lists rainwater management features (RMFs) presumed to achieve the performance targets, if properly designed, installed and maintained, and are accepted for use on properties within TFN. Natural, surface oriented RMFs will be encouraged over below ground, manufactured systems.

Table 4.5: Performance Targets by Land Use Classification

LAND USE CLASSIFICATION	WATER QUALITY POLLUTANTS OF CONCERN	PERFORMANCE TARGETS	ACCEPTABLE RMFs TO ACHIEVE PERFORMANCE TARGETS
Residential - Single Family	TSS	Basic	Amended topsoil Disconnected roof downspouts Rain Gardens Vegetated Bioswales Porous Asphalt Drives, Sidewalks, parking areas Sand Filters Filter Strips Stormwater treatment wet ponds Stormwater treatment wetlands Manufactured Filter Systems
Residential - Multi-Family	TSS O&G	Basic + Oil Control	Oil/water separator (API or coalescing plate type), plus RMFs listed under "Residential – Single Family"
Commercial – offices with primarily employee daily parking	TSS	Basic	Same as those listed under "Residential – Single Family"
Commercial – retail use with significant daily traffic (>100 vehicles per 100 m² of building) • Includes service station(s)	TSS O&G	Basic + Oil Control	Same as those listed under "Residential – Multi Family"
Industrial – low intensity use, with minimal truck traffic and primarily employee daily parking	TSS	Basic	Same as those listed under "Residential – Single Family"
Industrial – medium intensity use, with truck traffic and employee daily parking	TSS O&G	Basic + Oil Control	Same as those listed under "Residential – Multi Family"

Table 4.5: Performance Targets by Land Use Classification *(continued)*

LAND USE CLASSIFICATION	WATER QUALITY POLLUTANTS OF CONCERN	PERFORMANCE TARGETS	ACCEPTABLE RMFs TO ACHIEVE PERFORMANCE TARGETS
Industrial – high intensity use • Industrial machinery & equipment, and railroad equipment maintenance • Log storage and sorting yards • Railroad yards • Fueling stations • Vehicle maintenance and repair • Construction businesses	TSS O&G Trace Metals	Basic + Oil Control + Enhanced	Oil/water separator (API or coalescing plate type) plus: Stormwater Treatment Wetlands Stormwater Treatment Wet Ponds Media Filters Subsurface Infiltration Sand Filters Amended Sand Filters
Institutional (Schools; government; hospitals; cultural buildings)	TSS O&G	Basic + Oil Control	Same as those listed under "Residential – Multi Family"
Parks and Open Space (Buildings, parking lots and other hard surfaces)	TSS	Basic	Same as those listed under "Residential – Single Family"
Roads & Streets – low intensity use (<15,000 ADT) • Local roads • Lanes	TSS	Basic	Same as those listed under "Residential – Single Family"
Roads & Streets – high intensity use (>15,000 ADT) • Arterials / Highways • Collectors • High use intersections (>15,000 ADT on main road; >10,000 ADT on intersecting road)	TSS O&G (high) Trace metals	Basic + Oil control + Enhanced	Oil/water separator (API or coalescing plate type) plus: Stormwater Treatment Wetlands Stormwater Treatment Wet Ponds Media Filters Subsurface Infiltration Sand Filters Amended Sand Filters
Agricultural		Follow Applicable Provincial Rules and Guidelines for Agricultural Lands	

Implementation of water quality treatment facilities and best management practices on both private and public lands to achieve the performance targets is a requirement of the IRMP.

Building Roof Runoff

A frequent question or concern is the quality of runoff from building roofs. In the past it has often been assumed that roof drainage is generally "clean"; however, a number of references have noted that rainfall coming in contact with roofs as well as exterior building surfaces may be contaminated with a variety of pollutants. As noted in Table 4.3 above, wood preservatives, paint, uncoated metals, coal dust (from Port operations), biocides and pathogens (from animal droppings) can be washed off buildings. Vents on roofs (e.g., oven or grill vents from restaurants), can also deposit oil and grease on roofs. Further, atmospheric deposition of other particulates can find their way onto building surfaces, potentially contaminating runoff. TFN should require that developments consider potential pollutants from building roofs and outline mitigation approaches (e.g., avoid uncoated metals for roofs, walls and railings; avoid use of copper for gutters, drain pipes and other surfaces exposed to rain; use water repellent wood finishes on wooded treated with preservatives; and maintain or replace aging, deteriorating building surfaces before they contribute to NPS pollution).

4.3 Environment

4.3.1 Ditch Habitat Improvements

Given the lack of suitable habitat conditions in the ditches within TFN Lands, efforts to enhance ditches to form salmonid habitat and/or create connectivity to nearby watercourses that contain salmonids is costly and not necessarily the best use of funds to enhance overall habitat functions. Instead, focus of enhancement efforts should be directed to improvements to habitat function for wildlife, which in turn should also improve habitat conditions for non-salmonid fish species that may be present in the ditch network.

The ditch network within TFN provides habitat and food sources for aquatic and semi-aquatic wildlife and non-salmonid fish populations. Development design should maintain aquatic habitat where feasible. Ditches designated as "Class A" in Figure 2.8 would be a priority for wildlife habitat maintenance options. Ditch "riparian zone" improvements can be achieved by:

- Newly created or re-aligned ditches should incorporate habitat elements for wildlife.
- Ditches should have designated riparian zones and be managed as habitat for wildlife. Levels of protection for the riparian zones will vary, depending on the allowance for human access along trails and for equipment access for maintenance.
- Plantings in the riparian zones should be designed to meet land use objectives and may include provisions for pedestrian trails along one side of the ditch with vegetation plantings to afford some wildlife habitat, and dense plantings of indigenous vegetation on the other side to serve as more functional wildlife habitat.
- Removal of invasive species is an important consideration for function of riparian zones as wildlife habitat. Invasive and weedy species should be removed and those areas maintained, where feasible, until preferred plantings can take hold and are successful in the long term.

- Features such as small surface depressions along or in proximity to ditches can be designed as facilities to filter local runoff and, in conjunction with adjoining vegetated habitat, can function as habitat for wildlife. Appropriate setbacks for these features would be determined as part of the design process.

4.3.2 Ditch Infill Compensation

Ditch infills would constitute a loss of fish habitat as defined by the Fisheries Act (as infilling would result in losses of wetted and riparian habitat) and would be viewed as not meeting DFO's No Net-loss Policy, which states that loss of habitat should be compensated firstly within the same watercourse (in this case, the local drainage system) and if that is not possible, then a nearby watercourse. The amount of in-stream and riparian zone habitat would be calculated for a particular development area, and suitable compensation areas and measures would have to be identified. For ditch habitat, the "riparian zone" should be taken from the top of bank to the outward extent of existing vegetated habitat, and within the appropriate riparian zone (i.e., 15 metres from top of bank, but not including any roadway or other hard surface area). The ratio of habitat replaced to habitat lost would likely be 2:1. Compensation for habitat lost due to ditch infilling can best be achieved by designating specific areas for newly created habitat, and placing these within or adjacent to larger retained or managed habitat.

4.3.3 Protection of Intertidal and Marine Habitat

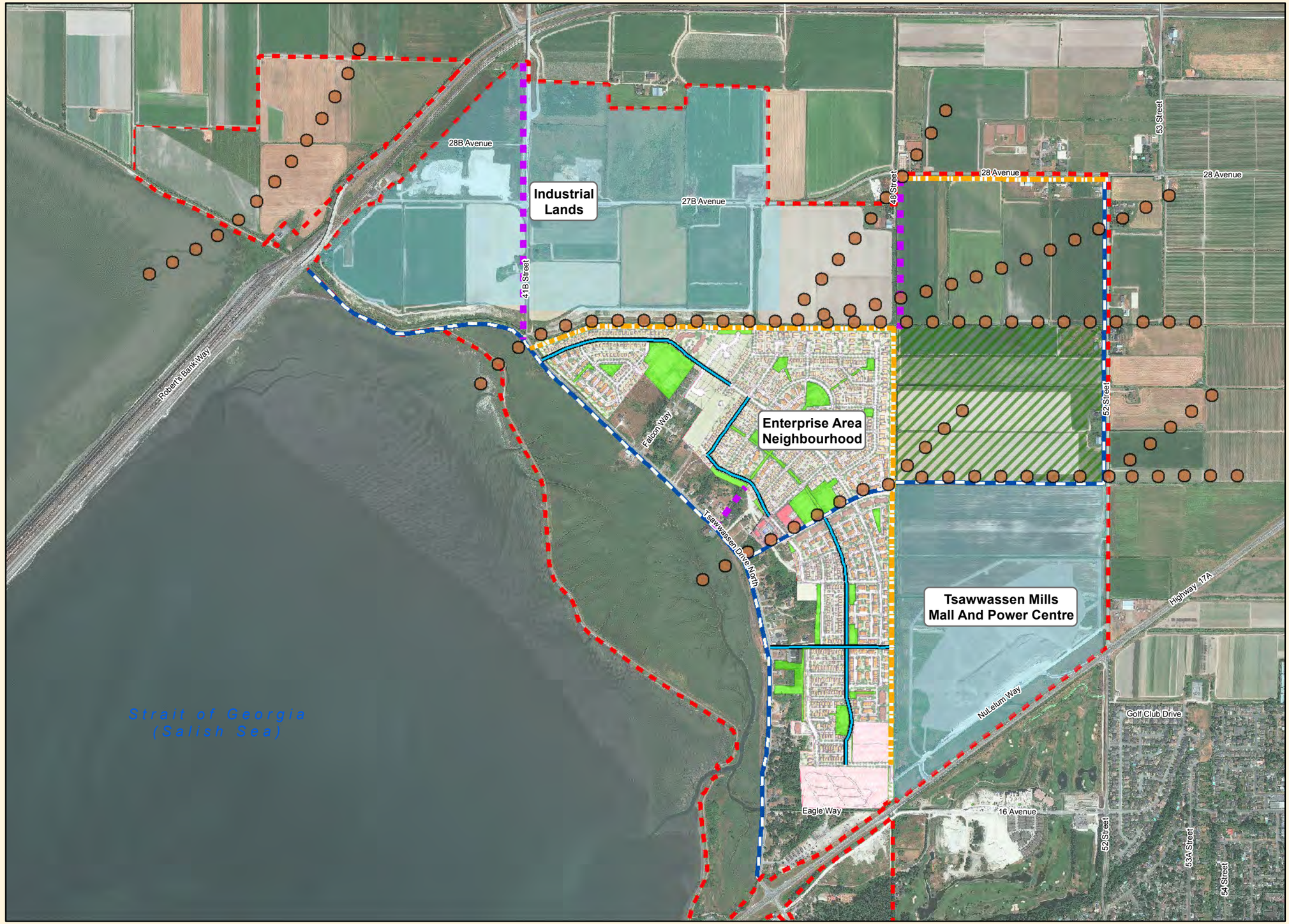
The IRMP can support the maintenance or enhancement of intertidal and marine habitat integrity by considering the inclusion of environmentally supported features such as:

- A long-term water quality monitoring program for discharges to the intertidal marsh habitat, with the intent of measuring discharge water quality against relevant guidelines for protection of aquatic life
- A vegetated buffer along the ocean side of the dike system, to discourage human access into the foreshore area. Plantings should be selected from species that are adapted to windblown and saline spray conditions, and should be monitored for a period of two to three years to assess survival and growth

4.3.4 Linkages and Connectivity

Future development at TFN provides an opportunity to incorporate wildlife movement linkages into the landscape. This can include smaller scale local movements, such as songbirds and small mammals along drainage channels and hedgerows, as well as broader movements, such as those of waterfowl and shorebirds between the farmlands to the east and the intertidal marsh habitats to the west. Providing for linkages, especially with respect to migratory and wintering birds, is of primary importance to conservation of bird populations that use the Roberts Bank IBA. Further, raptors make extensive use of the farmlands during the breeding season and during migration, and can continue to use the farmlands as foraging habitat. Proposed wildlife movement linkages are identified in Figure 4.10.

Smaller linkages can also provide recreation opportunities for humans, thus serving as multi-function movement linkages. Planning and design of these smaller linkages should strive to balance the needs of wildlife versus people; this can be accommodated by designating select linkages for wildlife or human use



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Legend

- ESA/Habitat Corridor (may include multi-use path)
- Multi-Use Path
- Wildlife Movement Linkage
- Local Road With Greenway
- Great Blue Heron Way*
- Managed Forest
- Park (Local, Linear, Neighbourhood)
- Tsawwassen First Nation (TFN) lands

*Location of Great Blue Heron Way is tentative pending further consultation.

Note: Orthophoto taken on July 31, 2013.

URBAN systems

Integrated Rainwater Management Plan

Environmental Linkages & Connectivity

Figure 4.10

0 250 500 1,000
Meters

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only, or for wider linkages (e.g., along large ditches) providing for people movement on one side of the linkage and for wildlife habitat and movement on the other side.

The IRMP provides an opportunity to secure and promote linkages and connectivity throughout TFN lands by:

- Incorporating linkages between riparian zones (particularly treed riparian habitat) wherever possible in community planning.
- Maintaining linkages among riparian vegetation, leave strips, forested habitat and the marine foreshore to facilitate habitat linkages in the landscape. These linkages can be used for movement and dispersal by various wildlife species.
- Enhancing existing green strips, including treed, shrub, and grass riparian habitat, to provide improved habitat for native amphibians and small mammals. Enhancement options could include planting shrubs and trees and placing woody debris which provides cover for wildlife.
- Using hedgerows, set-a-sides, winter cropping or laser leveling as sound and light buffers along watercourses. Developing these systems along large open channels where shrub or tree riparian habitat exists may reduce disturbance to riparian and aquatic species while adding habitat value.
- Planting larval food plants associated with butterfly species within riparian corridors. This may attract butterflies and other invertebrates to TFN lands. Butterflies and other invertebrates associated with riparian habitat provide a source of food for riparian insectivorous and birds and can promote biodiversity.
- Addressing possible conflicts between development and aquatic mammals, including reduction of aquatic habitat.

4.4 Multi-Functional Corridor Networks

Existing drainages and various corridors proposed for development on TFN lands present opportunities to combine a variety of rainwater management, environmental, habitat, circulation and amenity functions within linear public open space. The general layout of the recommended corridor network is shown on Figure 4.10. Key corridor network with multi-functional opportunities are described below.

4.4.1 48th Street

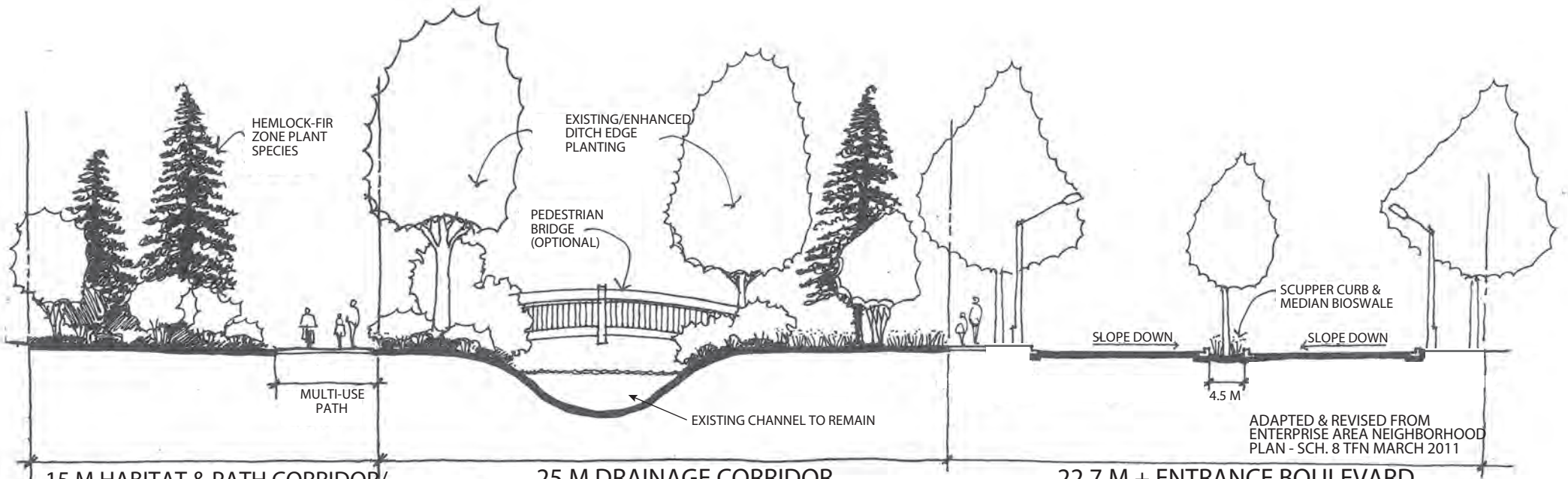
The 48th Street corridor consists of three component areas (Entrance Boulevard, Drainage Corridor and Habitat/Path Corridor) that could be integrated within a single system. A conceptual sketch of the 48th Street corridor is shown on Figure 4.11. The proposed drainage corridor and habitat/path corridor components are applicable to similar conditions elsewhere within proposed development at TFN.

Entrance Boulevard

Extending north from Highway 17A, the entrance boulevard will serve as the primary access to the Enterprise Area Neighbourhood, as well as an access point to the Tsawwassen Mills Mall and Power Centre development. The boulevard, as proposed in the Enterprise Area Neighbourhood Plan, includes two travel lanes in each direction separated by a median, with boulevards on each side of the road and a sidewalk on the west side. Rainwater management facilities and supporting landscape treatments are proposed as follows:

- Vegetated bioswale along central median; travel lanes sloped to drain to central median with reverse gutter along the outside edge and scuppered curb (similar to 41B Street in the TFN Industrial Lands)
- Amended growing media in vegetated bioswale and roadside boulevards to retain rainwater and support proposed plantings, including:
    - Street trees – ornamental deciduous species with moderately high evapotranspiration capacity, compatible with and adaptable to site conditions, and suitable to maintaining sightlines and physical clearances to traffic
    - Understorey plantings – grasses, forbs and shrubs suitable for naturalization with ultimate height less than 0.75m and compatible / adaptable to site conditions; concentrated in median
    - Turf grass – Drought-tolerant; concentrated in boulevards

FIGURE 4.11: 48TH STREET CORRIDOR (TYPICAL SECTION)



15 M HABITAT & PATH CORRIDOR/ GREAT BLUE HERON WAY (INLAND)
(SUBJECT TO ENVIRONMENTAL SETBACK AREA (ESA) REVIEW)

25 M DRAINAGE CORRIDOR
(SUBJECT TO ESA AND DRAINAGE REVIEW)

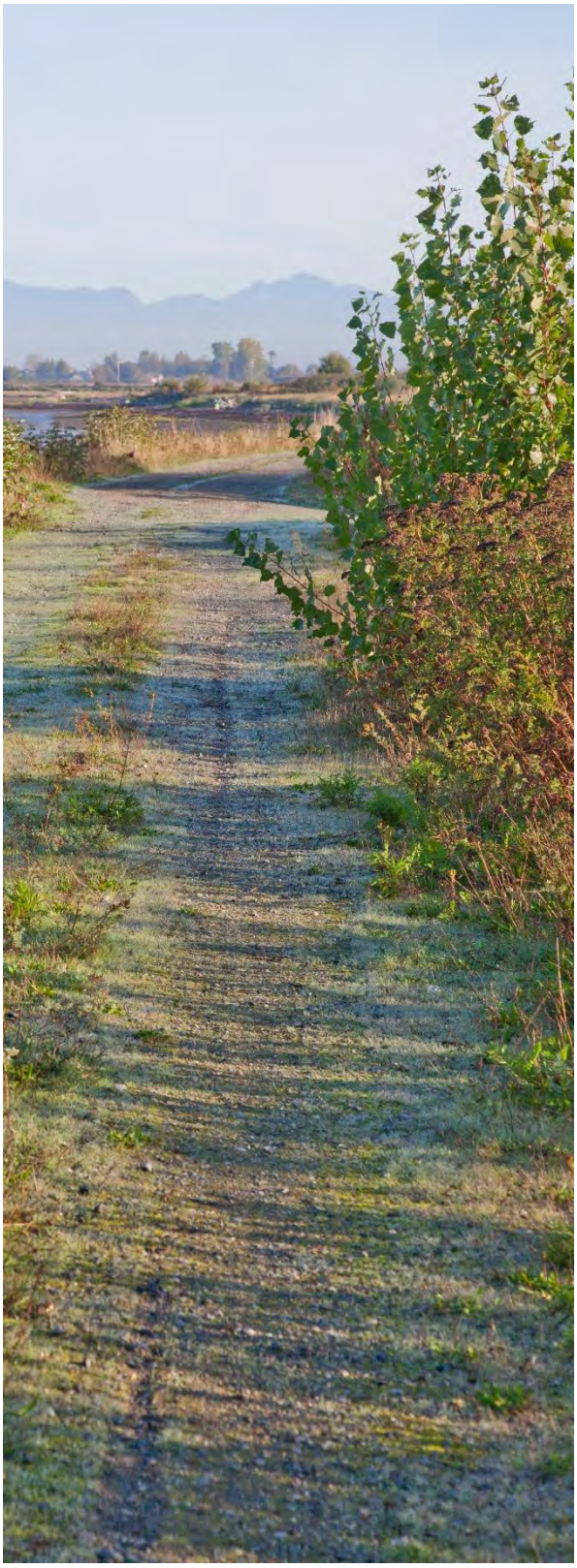
22.7 M + ENTRANCE BOULEVARD (48TH STREET)

*Location of Great Blue Heron Way is tentative pending further consultation.

Drainage Corridor

The 48th Street channel, located along the west side of the entrance boulevard, is an integral part of the overall drainage conveyance network. A wide corridor (to encompass the channel geometry and riparian setbacks on either side, anticipated to be at least 25 metres wide; further complemented by the habitat and path corridor / environmental setback area) is proposed to protect the channel operation, support water quality treatment, and provide a buffer between the entrance boulevard and proposed residential development to the west. Rainwater management facilities and supporting landscape treatments are proposed as follows:

- Continuous planted corridors along each side of the channel to manage and treat surface flows and promote water retention
- Naturalized planting scheme incorporating groves of trees and shrubs representative of Coastal Douglas Fir bio-geoclimatic zone, within an understorey of forbs and grasses to promote evapotranspiration. Planting scheme to be adaptable to site conditions and representative of a regionally appropriate and adaptable landscape
- Protection and enhancement of natural channel-edge planting to contribute to integrity and functionality of channel and provide riparian and bird habitat
- Maintenance access and pedestrian crossings to be resolved as part of preliminary design



Habitat / Path Corridor

This corridor, proposed to be 15 metres wide, includes components related to the protection of riparian habitat, provision of corridors for wildlife movement and habitat linkage, and accommodating active transportation and recreational connectivity. The proposed elements and treatments included in this corridor are applicable to other locations including riparian setbacks, environmental corridors and buffers along the east and north perimeter of the

Enterprise Area residential development area and inland segments of the proposed Great Blue Heron Way. The components of these corridors, depending on location, include some or all of the following:

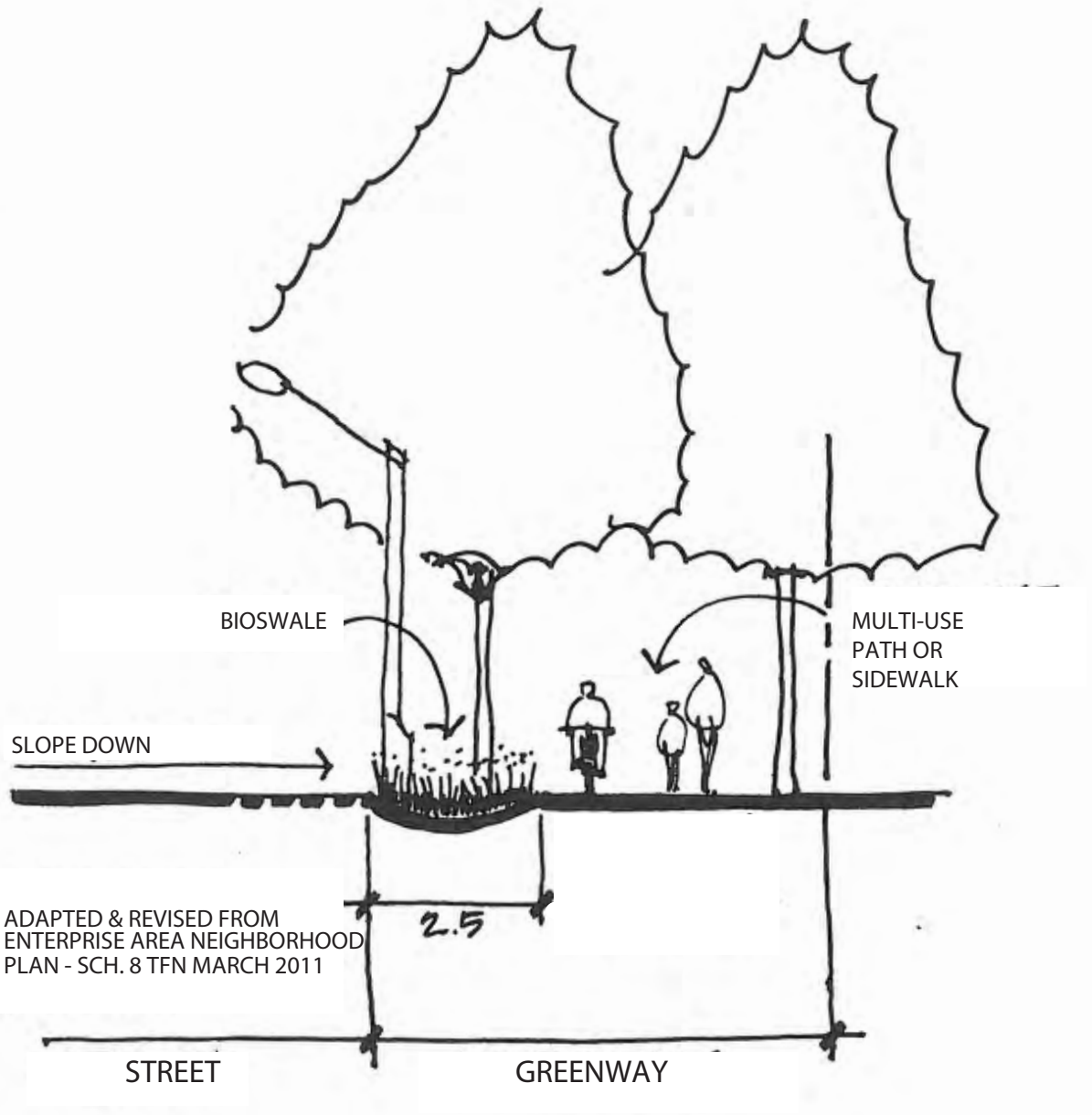
- Vegetated bioswales or other rainwater conveyance and retention elements
    - Naturalized planting scheme incorporating groves of trees and shrubs representative of Coastal Douglas Fir bio-geoclimatic zone, within an understorey of forbs and grasses to promote evapotranspiration. Planting scheme to be adaptable to site conditions and representative of a regionally appropriate and adaptable landscape
- Multi-use path for active transportation, recreation amenity and maintenance access
- Interpretation, public education and environmental art program elements

4.4.2 Local Roads

Local roads can incorporate greenways that provide rainwater management, active transportation and recreational connectivity, and streetscape enhancement. A typical section for a local road is shown in Figure 4.12. Components may include:

- Vegetated bioswale with amended growing media, ornamental trees and understorey planting similar to description for 48th Street Entrance Boulevard
- Multi-use path for active transportation and recreation amenity
- Permeable pavement (where appropriate) in parking lane and scuppered curbs along roadside edge of vegetated bioswale (or no curbs to allow overland sheet flow to bioswale)

FIGURE 4.12: LOCAL ROAD WITH GREENWAY (TYPICAL SECTION)



4.4.3 Great Blue Heron Way

Inland

Inland segments of the proposed Great Blue Heron Way network can incorporate many of the same elements and properties as the habitat / path corridor described above for 48th Street, including protection of riparian habitat, provision of corridors for wildlife movement and habitat linkage, and active transportation and recreational connectivity.

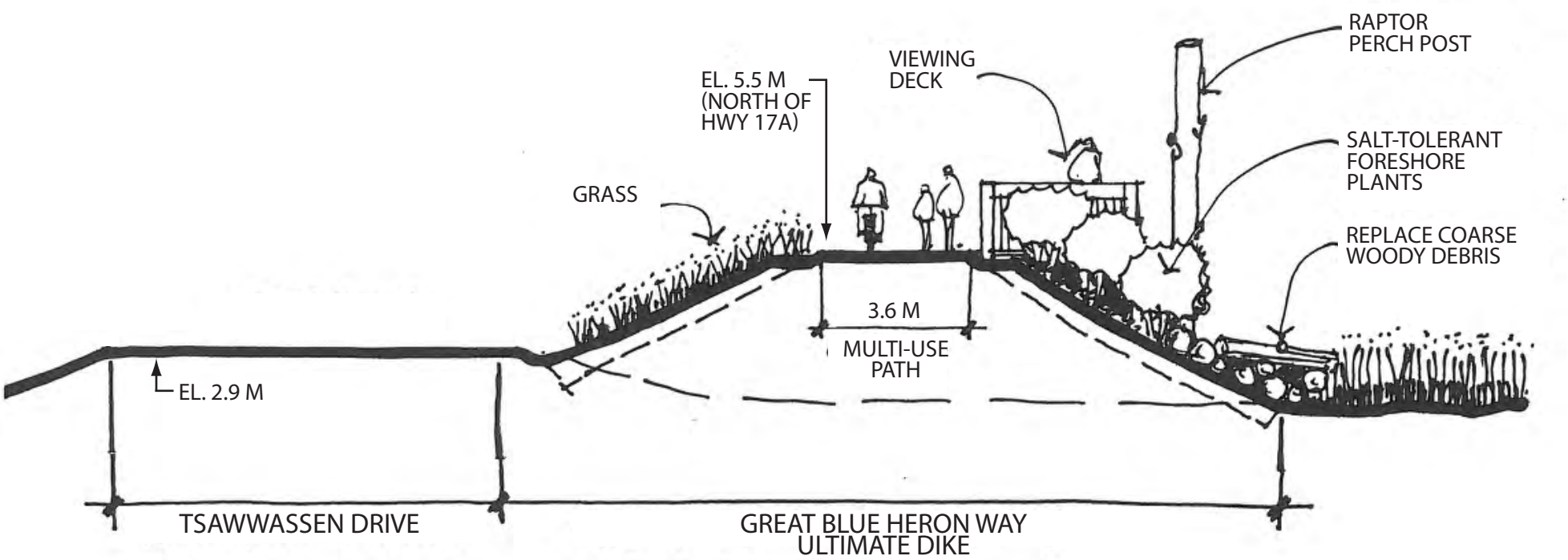
Foreshore

TFN may wish to consider incorporating the foreshore segments of the proposed Great Blue Heron Way network with future flood protection infrastructure. For instance, if dike improvements are selected to address future flood protection needs, the Great Blue Heron Way could be situated on top of the new dike; this is shown conceptually on Figure 4.13. The photo at right shows a similar arrangement in Richmond, BC.

Proposed elements could include:

- Continuous multi-use path along the top of dike, including stairs or ramps to inland connections as required
- Re-vegetation of inland dike slope to naturalized drought and salt tolerant native grasses
- Re-vegetation of foreshore dike slope to suitable drought and salt tolerant shrubs and forbs; planting scheme to discourage human access into the foreshore area
- Habitat enhancement with placement of coarse woody debris at base of foreshore bank and installation of coarse woody debris (logs) as raptor perches
- Viewing platforms, nature interpretation, public education and environmental art program elements

FIGURE 4.13: GREAT BLUE HERON WAY (FORESHORE)
AND ULTIMATE DIKE (TYPICAL SECTION)



*Location of Great Blue Heron Way is tentative pending further consultation.

4.5 Regulatory Framework Amendments and Additions

This section outlines recommended amendments and additions to TFN plans, regulations and programs that will enable TFN to work towards the IRMP Vision, Goals and Objectives, and achieve and maintain the recommended works described in this report.

A thorough review of TFN's regulatory framework has been essential to the IRMP process as the IRMP will be implemented within the context of this framework. An up-to-date set of regulations, policies, plans and programs will help to ensure the long-term success of the rainwater management program and will provide certainty for both TFN and the development community. Figure 4.14 provides a visual summary of TFN treaty, laws, acts, regulations, plans, policies and guidelines that pertain to rainwater management.

The review of TFN's regulatory framework has resulted in a comprehensive list of recommended amendments as well as new proposed programs and regulations. It is recognized, however, that priorities must be established, as it is not feasible to pursue all recommendations at one time. Table 4.6 highlights the highest priority recommendations with regards to TFN's regulatory framework. These initiatives will have the greatest ability to positively impact rainwater management on TFN lands. It is recommended that TFN concentrate on developing and implementing these regulations first.

Table 4.7 provides a detailed inventory of TFN's existing policies, regulations and acts, and proposes amendments as needed to support the IRMP.

While a number of amendments are proposed to existing TFN regulations, there are also new regulations and programs that are recommended to enhance and support the implementation of the IRMP. Details regarding these new regulations and programs are included in Table 4.8.

Table 4.6: High Priority Regulatory Recommendations

	RECOMMENDATIONS
1.	Finalize the MMCD Design Guideline Manual and Construction Specifications – Supplementary Specifications document
2.	Amend the Drainage and Sewer Regulation
3.	Establish an Erosion and Sediment Control Regulation
4.	Update the Capital Plan
5.	Update the Offsite Levies Regulation
6.	Amend the Landscape Guidelines

Figure 4.14: Tsawwassen First Nation Regulatory Framework for Rainwater Management

Treaty & Constitution	TFN Final Agreement & TFN Constitution Act				
Laws	Community Governance Act	Land Use Planning & Development Act	Financial Administration Act	Other Acts	
Existing Regulations	• Soil Transport, Deposit & Removal Regulation • Local Waterworks Regulation • Tree Regulation * • Drainage & Sewer Regulation * • Good Neighbour Regulation * • Other Regulations	• Consolidated Planning & Development Act • Zoning Regulation * • Offsite Levies Regulation * • Development Permit Guidelines Regulation * • Subdivision & Development Regulation * • Building Regulation *		• Other Regulations	
Proposed Regulations	• Cosmetic Pesticide Use Regulation • Erosion & Sediment Control Regulation	• Landscape Guideline or Regulation			
Statutory Plans & Policies		• TFN Land Use Plan • Enterprise Area Neighbourhood Plan			
Other Plans , Policies & Guidelines		• Integrated Rainwater Management Plan • Industrial Lands Master Plan • Enterprise Area Design Guidelines (draft) • TFN Sustainability Guidelines (draft) • Trails & Amenities Plan (in progress) * • Various Technical Studies	• Ten-year Capital Plan *		
Recommended Programs & Projects	See Table 4.8				

* Changes are proposed through this IRMP - see Table 4.7

Table 4.7: Recommendations for Amendments and Additions to TFN's Regulatory Framework

DOCUMENT NAME	PURPOSE	HOW IS THE DOCUMENT RELEVANT TO MANAGING RAINWATER?	SUGGESTED ACTION OR AMENDMENT	IMPLEMENTATION TOOLS OR RECOMMENDATIONS
		LAWS		
Land Use Planning and Development Act	To establish the legal framework for the management of lands, including the enactment of the Land Use Plan, Zoning Regulation, Subdivision and Development Regulation and other regulations pertaining to development and the overall use of land.	All of TFN's plans, policies and regulations, many of which address rainwater management, fall under the framework of the Land Use Planning and Development Act.	None.	n/a
		PLANS AND POLICIES		
Land Use Plan (2009)	To set the overall policy direction for land use on TFN lands. The Land Use Plan establishes long-range land use designations as well as broad policy statements regarding various matters, including environmental protection.	TFN's Land Use Plan has a direct influence on how TFN lands will develop in the future (i.e., where development will be permitted, the scale of development permitted, and the type of future development). These aspects of land use have a direct bearing on the amount of impervious area created in a community, and, consequently, on the amount of rainwater runoff generated. The Land Use Plan also makes direct mention of drainage and rainwater management in a number of policies. The Plan supports "green" rainwater infrastructure and the creation of a "Blue Ways" system.	None at this time.	n/a
Industrial Lands Master Plan (2009)	To prepare a master plan for the industrial zoned lands	The evaluation criteria developed as part of the planning process demonstrate the community's commitment to lower impact development and respect for the sustainable environment.	None at this time.	n/a
Residential / Commercial Enterprise Area Neighbourhood Plan (2011)	To establish the overall land use direction for approximately 110 ha of primarily Tsawwassen Fee Simple Interest (TFSI) lands, centered on the area designated as "residential/commercial enterprise" in TFN's Land Use Plan.	Neighbourhood design impacts the density and form of development, and therefore, the amount of impervious area, runoff and nonpoint source pollution generated.	None at this time.	n/a
Enterprise Area Design Guidelines	To provide design guidance for public areas within the Enterprise Neighbourhood Plan area.	Rainwater management is an integral function of public open space, linear corridors and parks.	Ensure that the scope of the Guidelines addresses rainwater management function in combination with associated environmental, habitat, active transportation, recreation and cultural landscape functions. Extend guidelines to cover other development areas.	Amend the Design Guidelines.
Capital Plan	To outline the capital works projects.	There are several different components, on both private and public lands, that comprise the overall IRMP strategy. Components on private property will not form part of the community wide capital plan, nor generally do local servicing components which will be the responsibility of developers. The Capital Plan usually identifies works and initiatives which are the responsibility of the broader community to implement. This may include physical infrastructure, studies, monitoring programs, etc.	Update the Capital Plan for trunk drainage infrastructure works identified in Figure 4.9 and Table 4.2 of the IRMP. In addition, future studies, programs, and monitoring may be included. Once all candidate items are identified, implementation and cost recovery strategies are also needed.	Update the Capital Plan Review need to update cost recovery strategies
		REGULATIONS		
Zoning Regulation (2009)	To deal with the use of land, siting of facilities, density of development, parking requirements and more.	Zoning regulations impact the amount of impervious surfaces on a given parcel of land, most notably through minimum parking space requirements and through maximum parcel coverage and/or setback requirements. The Zoning Regulation also stipulates minimum setbacks from water bodies and watercourses (i.e., 15 m setback from the boundary of any non-fish bearing watercourse and 30 m setback from the boundary of any fish-bearing watercourse).	Review zoning standards; similar to commercial zones (C-3 and C-4), include provisions for industrial and multi-family sites that specify a maximum impervious footprint or a minimum pervious site coverage.	Amend the Regulation, including the following items: ▪ Impervious cover ▪ Reduced parking standards ▪ Lot coverage requirements

DOCUMENT NAME	PURPOSE	HOW IS THE DOCUMENT RELEVANT TO MANAGING RAINWATER?	SUGGESTED ACTION OR AMENDMENT	IMPLEMENTATION TOOLS OR RECOMMENDATIONS
		REGULATIONS		
Development Permit Guidelines Regulation (2009)	To mandate the issuance of a development permit prior to: subdivision of land; alteration of land, including but not limited to clearing, grading, filling, blasting, preparation for or construction of services and roads; and/or, construction of, addition to or alteration of a building or structure.	The Development Permit Guidelines require that a rainwater management strategy and conceptual plans be prepared at the development permit stage. The regulation could be expanded to include requirements that will better achieve environmental and rainwater management objectives by addressing issues such as runoff treatment, site grading, landscaping and other rainwater management features (RMF's).	Determine the suitability of incorporating the following requirements: ▪ Runoff quality treatment ▪ Public RMF's within roadways and other public spaces ▪ Private RMF's for commercial, industrial, and multi-family development Amend the Environmental Development Permit as needed for consistency.	Amend the Regulation
Subdivision and Development Regulation (2009)	To address the provision of works and services in relation to the subdivision and development of land.	The Regulation includes a requirement for parcel holders to "provide… drainage works including surface and underground collection, conveyance and treatment systems," designed by a Professional Engineer in accordance with Master Municipal Construction Document (MMCD) Design Guideline Manual, the MMCD Specifications and Standard Drawings, and any supplementary TFN design criteria, specifications and standard drawings as issued and amended from time to time.	▪ Finalize and the MMCD Design Guideline Manual and Construction Specifications – Supplementary Specifications document ▪ Adopt works and services agreement template.	Review updated MMCD Design Guideline Manual and Green Design Guideline Manual and refine TFN supplemental standards and criteria if appropriate.
Drainage and Sewer Regulation (2009)	To regulate the connection to, and discharge of, wastewater and stormwater from a private parcel to the respective public systems (sanitary and drainage).	The Regulation aims to protect the storm sewer or community drainage system by prohibiting the discharge of wastewater, however is limiting in the fact that stormwater is excluded from the definition of "wastewater". Therefore, the current regulation does not currently apply to stormwater runoff quality.	▪ Expand definitions and description of prohibited substances in order to better regulate stormwater runoff. ▪ Coordinate language with text on stormwater flows in the "Good Neighbourhood" regulation. ▪ Consider inclusion of penalties for Owners failure to operate and maintain on-lot RMF's which then lead to non-compliant discharge.	Amend the Regulation
Offsite Levies Regulation (2009)	To establish the levies for new developments on Tsawwassen Lands. Levies are collected because new development imposes burdens on the Tsawwassen Government for the cost of providing, constructing, altering or expanding community infrastructure.	The levies collected are in part used to pay for the cost of providing, constructing, altering or expanding sewer, and maintaining water works and drainage infrastructure.	Include costs for off-site drainage infrastructure improvements as part of the levies.	Continue regularly amending the Capital Plan and the Offsite Levies Regulation.
Soil Transport, Deposit and Removal Regulation (2011)	To set out the requirements for the transport, deposit or removal of soil on TFN lands.	The Regulation requires the importation of clean fill and contains other provisions aimed at protecting the natural watercourses and fish habitat.	None at this time.	n/a
Building Regulation (2009)	To regulate construction within TFN in the general public interest – specifically for reasons of health, safety and the protection of persons and property.	The Regulation addresses site drainage and requires that each lot must be graded to drain into a TFN drainage system or a natural watercourse. Runoff must not flow onto adjacent lots.	This document has linkages to the Subdivision and Development Regulation, and therefore these two documents must be in concert with each other and not conflict. The content of the Building Regulation will ultimately depend on the content and application of the Subdivision and Development Regulation. The Building Regulation should also consider standards and criteria for lot grading, water quality treatment, roof leader connection / disconnection, drainage service connections, landscaping, and private RMF's. While initial development of the land will likely be regulated through the subdivision and development process, consideration should be given to the rebuilding of lots in the future when rezoning or subdivision processes are not triggered.	Amend the Regulation

DOCUMENT NAME	PURPOSE	HOW IS THE DOCUMENT RELEVANT TO MANAGING RAINWATER?	SUGGESTED ACTION OR AMENDMENT	IMPLEMENTATION TOOLS OR RECOMMENDATIONS
Tree Regulation (2009)	The purpose of a tree management regulation is to prohibit the cutting, removal and damage to trees. Protecting trees can help prevent the increase in rainwater flow and erosion due to development.	The Regulation aims to protect trees which intercept rainwater, thereby reducing runoff volumes and water quality treatment requirements.	Consider expanding the definition of "protected tree" to include other species that are critical to rainwater objectives. The underlying rainwater-related objective for the preservation of trees is to promote and preserve the canopy cover in order to reduce runoff volumes. It could also include provisions for replanting compensation should removal of an existing tree be justified.	Amend the Regulation.
		TECHNICAL STUDIES		
Traffic Impact Assessment (In Process)	To assess the impact of future development on the surrounding transportation network. The Transportation Plan will also recommend necessary mitigation measures to accommodate the anticipated future traffic conditions.	Paved or impervious areas such as roadways require rainwater mitigation measures to address runoff (peak flow, volume and quality). Further, increased traffic volumes, particularly those that may be commercial or industrial in nature, will reduce runoff quality due to greater pollutant accumulations.	None at this time.	n/a
Bulk Water and Sanitary Trunk Master Plan (Final Draft)	To present a servicing strategy that will allow the Tsawwassen First Nation to provide consistent levels of water and sanitary sewer service through to the build out of its lands.	The Plan recognizes the integrated nature between the Plan and the IRMP.	Account for irrigation of landscaped area, as per Landscape Guideline or Regulation.	n/a
Offsite Levies Report (2013)	To provide recommendations for cost recovery strategies and legislation in support of future growth.	As the community grows, infrastructure expansion and upgrades are required to maintain adequate service levels. Some of this infrastructure directly pertains to the rainwater management system.	Developing a dedicated stormwater utility charge to fund implementation, operation and maintenance of drainage / stormwater management systems.	Creation of a dedicated "stormwater utility" charge.
Industrial Lands Environmental Assessment (2010)	To set out the inventory and assessment of environmental, social and archaeological resources, as well as to identify the environmental effects of industrial development on the lands.	The Assessment includes a section which addresses drainage and surface water (Section 5.2), as well as sections on surface water and water quality.	None at this time.	n/a
Industrial Lands Design Report (09/2010)	To establish design and construction drawings for municipal infrastructure works and the Trunk Watermain from the GVWD supply point to the TFN community.	The Report addresses the existing site drainage conditions and also proposes improvements to the existing drainage system. The Report identifies TFN's need for an integrated rainwater management plan.	None at this time.	n/a
		PROJECTS AND PROGRAMS		
Sustainability Program (In Process)	To guide the development of TFN lands in a manner that achieves a high level of sustainability.	As identified through this IRMP, there are opportunities to implement rainwater management measures which contribute to the overall sustainability of a community.	None at this time.	n/a
Stormwater Utility Feasibility Report (Final Draft)	To provide a financially sustainable approach to long-term funding for TFN's stormwater management activities.	Develops a stormwater utility rate based on a "property class" approach for single family residential properties, and an impervious area approach for commercial, industrial and institutional properties.	None at this time.	n/a

Table 4.8: Recommendations for New TFN Regulations, Guidelines and Programs

NEW DOCUMENT OR PROGRAM RECOMMENDED	PURPOSE AND DESCRIPTION	SUGGESTED ACTIONS	IMPLEMENTATION TOOL
RECOMMENDED REGULATIONS			
Cosmetic Pesticide Use Regulation	There are approximately 40 such bylaws in BC. The purpose of a cosmetic pesticide use regulation is to restrict or prevent that application of pesticides for cosmetic purposes. There is some degree of controversy as to their effectiveness and enforcement. There is also some controversy whether the regulation should allow restrictive use or outright banning. It is also generally viewed that education programs must be used in tandem with regulation.	Engage in a discussion as to whether or not a cosmetic pesticide use regulation is an appropriate regulatory tool for TFN and consider education programs that would support it. Decision makers should explore and discuss the dangers associated with cosmetic pesticide use such as risks to human health and the potential for the contamination of surface and groundwater.	Research the success of such regulations in other jurisdictions. Gauge level of support for the regulation and if sufficient support exists, begin the regulation preparation process.
Erosion and Sediment Control Regulation	These are commonly applied in relevant municipal jurisdictions. An Erosion and Sediment Control Regulation aims to control construction processes and includes specific requirements for controlling the amount of TSS (total suspended solids) leaving a site. Reducing the discharge of sediment into the drainage system will reduce operational and maintenance challenges and would reduce the degradation of environmental quality within TFN's drainage system and the tidal estuary.	Engage in a discussion as to whether or not an erosion and sediment control regulation is an appropriate regulatory tool for TFN. Question whether or not such a regulation would be effective in helping TFN achieve its Goals and Objectives.	Gauge level of support for the regulation and if sufficient support exists, begin the regulation preparation process.
DESIGN/LANDSCAPE ARCHITECTURE GUIDELINES FOR CONSIDERATION			
Landscape Guidelines	Healthy, natural and suitably developed landscapes contribute significantly to rainwater management by absorbing, infiltrating, transpiring and treating soil moisture to reduce demand and impacts on natural environments and drainage systems. While landscape guidelines have been adopted for the Enterprise Area, TFN could consider developing / extending the guidelines to cover all of TFN's lands. These guidelines would separate content that would otherwise be amended into existing regulations. It would provide direction and requirements for protection, planning, design, construction and maintenance of private and public landscaped areas.	Consider the development of landscape guidelines to: • apply to natural and developed private and public landscapes • consolidate and rationalize landscape references and standards from other documents • address rainwater function of landscape • address environmental, habitat, aesthetic and cultural objectives • define standards and specifications for selection, design, planting, establishment (including irrigation requirements) and maintenance (including invasive species removal process) of vital and sustainable landscapes including growing media, amended topsoil and grass seed.	Gauge level of support for a dedicated document, and if sufficient support exists, begin the guideline preparation process. The advantage of a dedicated document would be its broad application from a single document and easier maintenance over time. Alternatively, this information would be incorporated in both the subdivision and servicing regulation and the building regulation.
PROGRAMS AND PROJECTS FOR CONSIDERATION			
Community Education Program	Purpose of the program is to encourage a community-wide understanding and knowledge of rainwater related issues and best practices. The implementation of a community education program will help to foster support for rainwater management initiatives being conducted by TFN. Community education may be particularly suitable in established neighbourhoods where there is opportunity for existing property owners to implement RMF's on their own property.	Implement public education programs. Some key actions may include: ▪ Articles in weekly community notice ▪ Documents for new land owners and tenants ▪ Ongoing distribution of pamphlets ▪ Website ▪ School programs ▪ Communications plans (e.g., with local businesses) ▪ A public art program which places an emphasis on environmental art and exploring water Consider separate education program for Tsawwassen Bluffs properties in coordination with Delta.	If there is support for the program, develop goals and objectives before beginning the implementation process.
Pilot Project (1): Showcase Rainwater Management Practices	Purpose of the program is to demonstrate leadership for the use of sustainable rainwater practices. By demonstrating success "on the ground,"	▪ Discuss whether or not there is support for the implementation of a TFN showcase RMF project. This would include gauging support from major development	If there is support for the program, determine how the program is to be funded, develop goals and objectives for the program and then develop an implementation plan for the Project.

NEW DOCUMENT OR PROGRAM RECOMMENDED	PURPOSE AND DESCRIPTION	SUGGESTED ACTIONS	IMPLEMENTATION TOOL
	residents will become more familiar with implementing and managing RMF's and more likely to implement RMF's on their own private property.	applicants. ▪ Consider opportunities to connect project to TFN's Art and Culture objectives, by utilizing public art to showcase rainwater management ▪ Discuss what RMF's should be demonstrated as part of the pilot project (i.e., rain gardens, pervious pavement, planter boxes, rainwater harvesting, etc.) ▪ Consider opportunities to integrate RMF with other objectives (e.g., planting medicinal plants in passive green space areas or rain gardens, use of ALR or passive green space for community gardens to grow food)	
Pilot Project (2): Native Planting Schemes	Purpose of the program is to test the implementation and establishment of native/naturalized planting schemes as well as to test invasive plant control/eradication – especially for habitat and foreshore corridors. There may be an opportunity to tie such a program in with the community's expressed desire to use RWM features to grow medicinal plants.	Assess need and potential value of pilot programs in relation to existing knowledge and capacity to implement and maintain proposed treatments, priority and commitment to long-term landscape solutions and availability of funding support including potential research and development grants and partnerships with educational and environmental organizations. Gauge support from major development applicants to contribute.	If there is support for the program, begin to determine the parameters of the program and look into funding and partnership opportunities
		PROGRAMS AND PROJECTS FOR CONSIDERATION	
Urban Tree Planting Program	Purpose of the program is to promote increased tree planting on public and private lands. Tree planting and increased tree canopy cover is an effective way to promote environmental health and decrease rainwater runoff.	Host a community event to inform the community about the value of trees for rainwater management and environmental objectives, and identifies preferred species for planting. May want to consider an initial phase focused on TFN members with longer-term extension to future developments. Incentive opportunities (e.g., tree subsidies or giveaways) and logistical considerations should be reviewed. Planting criteria, species selection and landscaping requirements should also be well-defined.	If there is support for the program, begin to determine the parameters of the program and look into considerations regarding species selection. Potential tools would include the Landscape Guideline or Regulation (see prior page), Character Development Permit Regulation and Public Realm Guideline.
Incentive Programs	Purpose of the program is to provide financial incentive to implement on-lot RMF's on private property. The incentive program should also consider the long-term maintenance of the on-lot RMF's.	Discuss the suitability of a community-wide incentive program to encourage the implementation of on-lot RMF's on private property.	If there is support for the program, integrate the program with IRMP and link the program to enforcement measures
Operation and Maintenance of RMF's on private property	Purpose of the program is to identify long-term operation and maintenance requirements for RMF's on private property, including timelines, responsibilities and costs. Focus would be on commercial, industrial, institutional and multi-family residential sites.	Evaluate the need for Operation and Maintenance requirements to be described and enforced on private property.	If there is support for the program, include the following elements: ▪ For RMF's on commercial, industrial, institutional and multi-family sites, there are a number of ways in which TFN can enforce that adequate maintenance and upkeep takes place. Some of these options are as follows: o TFN could require a covenant to be placed on the title of the property. This is a very common technique that is expected to be applied here. o TFN could develop a regulation which would allow enforcement if RMF's weren't maintained. This option is more labour intensive to enforce. The DP Guideline could recognize it, but its specifics and enforcement would be better suited for the Drainage and Sewer Regulation. o TFN could require the property owner to sign a maintenance agreement, which would carry a financial penalty if the works were not maintained. Not commonly practiced to date, but has received increasing consideration given the movement towards on-lot private controls. May be best suited through the Drainage and Sewer Regulation. o TFN may seek private RMF's to be designated in statutory RoW. A security or bond could be collected to ensure that the RMF's are properly maintained over a set period of time. This is commonly done, with terms typically being for 125% of capital value and for one year.

4.6 Future Studies

4.6.1 Flood Protection

With sea levels predicted to rise by 1.0 metres by the Year 2100, and land predicted to subside by 0.2 m in the same time period, the current dike system will not be adequate to protect the TFN community in the future. Therefore, options to provide improved flood protection to the community should be explored.

The Province released a report[10] in 2012 on flood protection measures and associated costs to address sea level rise. The report is intended for planning and program development only, and recognizes that predicted rates of sea level rise, and thus flood protection levels, will likely need to be refined as more data becomes available. The report suggests that a dike system with a top (crest) elevation of 5.5 metres would be required north of Highway 17A, and 7.9 metres south of Highway 17A, to provide adequate flood protection for the community to the Year 2100. Figure 4.12 showed a potential configuration for flood protection measures, based on the dike height recommendations in the Delcan report. If this approach is followed, it is recommended to leave Tsawwassen Drive (i.e., the existing sea dike) at its current elevation, and construct a new sea dike between Tsawwassen Drive and the foreshore / intertidal area to the recommended elevation. The proposed Great Blue Heron Way multi-use trail system could be situated on the top of the new dike.

Given the proximity of flood protection measures to the TFN community housing areas, the proposed increase in dike height may be of concern to TFN members. TFN should consider alternate approaches to and/or alternate alignments for future flood protection infrastructure. Building on the IRMP, it is recommended that TFN conduct a flood protection study to review and assess the suitability of various alternatives for providing flood protection to the TFN community in the future. The study should also consider approaches to funding flood protection measures, recognizing that flood protection is a regional

[10] Cost of Adaptation – Sea Dikes &alternative Strategies, Final Report. 2012.

issue that will involve municipalities adjacent to the Fraser delta and Boundary Bay. The 2012 report also recommends that a regional flood protection strategy should be led by the Province.

4.6.2 Community Lands

TFN's community lands, previously shown on Figure 2.5, consist of the existing development along Tsawwassen Drive North, as well as Falcon Way and Eagle Way. The filling of lands east and north of the community lands to facilitate the development of the Enterprise Area Neighbourhood, combined with future flood protection upgrades, will result in the community lands being appreciably lower in elevation than the surrounding area. This poses an increased risk of flooding to these properties unless an adequate drainage system is implemented. A similar situation also exists for community lands between Highway 17A and the Tsawwassen Bluffs.

Currently, there is no formal drainage system in place to service the community lands; however, TFN has recently initiated a drainage study to evaluate servicing options for lands north of the TFN Administration building. The study, along with future studies for the remaining community lands, should consider the IRMP recommendations when identifying and evaluating drainage servicing options for the TFN community lands. The current study is expected to be completed in early 2014, with the remaining studies anticipated to begin by mid-2014.

TFN should also explore opportunities to encourage their members, through educational programs and pilot projects, to incorporate sustainable rainwater management approaches on their properties. Examples may include initiating a rainwater harvesting and reuse program (e.g., subsidizing the costs to purchase rain barrels for individual homes), "Adopt a Rain Garden" and/or "Plant a Tree" programs where community members could volunteer to construct a rain garden or plant appropriate tree species on private property to capture and retain rainwater runoff, etc. (see Section 4.5 for recommended program details).

4.6.3 Tsawwassen Bluffs

The Tsawwassen Bluffs are particularly sensitive to the impacts of surface rainwater runoff and the effects of subsurface groundwater seepage on slope stability. While appreciable redevelopment is not

anticipated on the Bluffs, opportunities and approaches for TFN to educate and inform property owners of the impacts of land use activities on runoff generation and slope stability should be explored. This may include brochures, website postings and/or onsite meetings with property owners to discuss aspects such as overwatering of lawns, incorporating native plants and grasses that require less irrigation to thrive, directly connecting roof downspouts to the public drainage system, retaining natural vegetated areas adjacent to the top of the slope (rather than ornamental grasses), avoiding mass removal of trees and vegetation to improve views, etc. It is recommended that TFN work with the Corporation of Delta on this educational initiative, as several properties situated at the top of the Bluffs are within Delta.

TFN is currently developing an action plan to address the overall stability of the Tsawwassen Bluffs. In order to identify physical measures of improving rainwater runoff capture and safely conveying it down the Bluffs, it is recommended that a more in-depth drainage study be conducted for the Tsawwassen Bluffs as part of the action plan. This study can verify flows in the local drainage system and identify required infrastructure improvements for safe conveyance, define major system conveyance routes that avoid instability prone areas of the bluffs, and identify and resolve inlet constrictions that may be impeding the capture of rainwater runoff by the local drainage system. Again, this study should be coordinated with the Corporation of Delta, as part of the drainage catchment area is situated in Delta (and therefore a portion of the rainwater runoff is generated by Delta).

5.0 How Does TFN Ensure that the IRMP Stays On Target?

5.1 Key Performance Indicators and Targets

Indicators and targets are needed to evaluate the proposed development scheme and to determine the development's level of success in achieving the IRMP goals and objectives. The overall approach in selecting indicators and targets is to respect the functions that are unique to the watershed, and to choose targets that are both quantifiable and a good representation of the indicator. It should be noted, however, that the targets may be subject to change over time based on the findings of the Adaptive Management Program; a program defined in Section 5.2.

Indicators and targets have been selected for three fundamental objectives; flood control, water quality, and habitat.

Indicator #1 – Frequency and Extent of Flooding

Target:

- Not to exceed current levels. Given that flood risk is dependent not only on land use changes but on variable climatic conditions as well, this target will need to be evaluated with direct monitoring and subsequent periodic predictive modeling of design events through recalibration.

Indicator # 2 – Water and Sediment Quality

Target:

- Water and sediment quality parameters, as described in the Adaptive Management section, are stable, or ideally, improved. Note, however, that salinity is expected to be negatively influenced by rising ocean levels and can not necessarily be attributed to development changes.

INDICATOR # 3 – OPEN CHANNEL RIPARIAN HEALTH

Target:

- A minimum of 80% survival rate of endemic or planted endemic vegetation for each of the first three years after planting along any new or re-located Class A drainage channel.
- Invasive species (e.g., Blackberry) within the Class A drainage channel and immediate riparian zone are minimal and do not dominate the endemic or planted endemic vegetation.

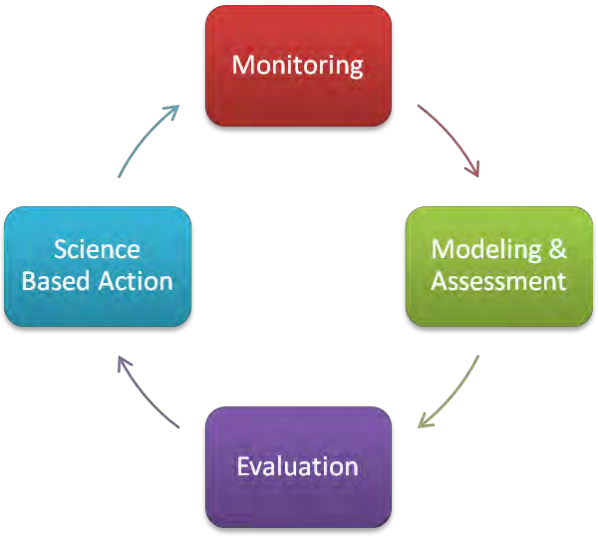
5.2 Adaptive Management Program

Metro Vancouver recently released the draft *Monitoring and Adaptive Management Framework* (AMF) report (October 2013). This report is intended to address the Ministry of Environment's (MOE) Approval Condition 7 of Metro Vancouver's Integrated Liquid Waste and Resource Management Plan (ILWRMP). The draft report outlines an approach to water quality, hydrometric (flow) and benthic invertebrate monitoring that considers the type of stream system. Since all ditches within TFN lands are considered lower gradient streams (<1% slope), only water quality and hydrometric monitoring would apply.

As TFN is not currently a member of the GVS&DD (through which the ILWRMP and ISMP monitoring requirements are administered), the draft AMF, once finalized, would not strictly apply to TFN; therefore the adaptive management program described herein is tailored to suit the specific needs of TFN, resulting in a similar, though not identical, approach to monitoring and adaptive management. If TFN becomes a member of the GVS&DD in the future, the program described below could be refined where needed to match the AMF requirements, if it were required.

There are many variables and influences that will ultimately dictate the performance of the management systems and whether or not the fundamental IRMP goals and objectives are being met. An adaptive management program, as shown on Figure 5.1, is a cyclical process of monitoring and assessment.

Figure 5.1: IRMP Adaptive Management Program



5.2.1 Monitoring

Monitoring is critical to the success of an Adaptive Management Program, and must be done in many forms. TFN has control over activities within its lands; however, actions, activities, and land uses within, or by, other jurisdictions will affect conditions both within TFN and the foreshore area. These include Corporation of Delta in particular, plus Port Metro Vancouver, BC Ministry of Transportation and Infrastructure, and BC Ferries. We recommend that TFN seek opportunities for partnerships with one or more of these entities to co-fund monitoring activities, collect or share data and results, and undertake other activities intended to protect and enhance the local environment. The recommended types of monitoring are described below, with proposed monitoring sites identified on Figure 5.2. Estimated costs to establish and maintain the programs are provided in Section 5.2.4.

Precipitation Monitoring

Precipitation monitoring will be a key aspect of the monitoring program, as precipitation trends are anticipated to shift over time as a result of climate change. While climate monitoring stations exist in the general area, it would be advantageous to have a local station to provide site specific information and ensure that monitoring results are accurately understood. Alternatively, TFN can work with Metro Vancouver to obtain precipitation data from the DT55 Ferry Road pump station gauge, which was utilized for the IRMP.

If a new precipitation station is endorsed by TFN, it is proposed that this station be considered a permanent station collecting precipitation data in 5 minute increments. It would be advantageous for this station to be hard wired to an electric source and be equipped with a communicator for automated data downloading. There is flexibility in where this equipment is installed, but ideally it will be placed in a secure location within a community facility, such as an operations centre, administrative building, or the like.

Effectiveness Monitoring

The second form of monitoring will measure the effectiveness of specific management features. Monitoring should be continuous, or at least frequent, and data collected is to be assessed against the predicted values.

Pump Stations

The pump stations represent the most significant management device that will govern drainage conveyance and flood protection performance, therefore monitoring of these facilities is key to the effectiveness monitoring program. It is recommended that the Brandrith and Industrial Lands pump stations be monitored, with an option to monitor the Deltaport pump station as well. All stations should collect, at minimum, the following data at 5 or 10 minute increments:

- Run time and flow rate (particularly if variable drive pumps) of each pump
- Water levels on the intake and outlet sides of the stations
- Data to assess relative contribution of flood boxes versus pumps

With predicted sea level rise being a significant aspect of flood risk long term, monitoring of the stations, and particularly water levels on the outlet side of the stations, will be valuable for tracking climate change impacts.

TSAWWASSEN FIRST NATION
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Legend

- Drainage Manhole
- Water and Sediment Monitoring Station
- Drainage Pump Station
- Drainage Pump Station with Flood Box
- Drainage Pipe
- Culvert
- Primary Ditches
- Class A Ditches
- Dyke
- Beach Grove Pump Station Catchment
- Brandrith Pump Station Catchment
- Deltaport Pump Station Catchment
- Tsawwassen First Nation (TFN) lands
- IRMP Study Area

Note: Orthophoto on west half of figure was taken on July 31, 2013.
Orthophoto on east half of figure was taken in 2008.

URBAN systems

Optional:
Deltaport Drainage Pump Station

Continuous flow and water level monitoring

Water and Sediment Monitoring Stations

(1) Continuous water quality (pH; temperature; D.O.; turbidity; salinity; conductivity)
(2) Monthly water quality (total and fecal coliforms, total metals)
(3) Annual sediment quality (moisture; pH; organic and inorganic carbon; total metals; PAHs; EPHs)

Industrial Lands Pump Station

Continuous flow and water level monitoring

Install vegetated buffer pilot project on ocean-side of dike (50m long); location to be determined.

Monitor condition of all vegetated buffers on ocean-side of dike annually.

Brandrith Drainage Pump Station

Continuous flow and water level monitoring

Optional:
28th Ave Irrigation Pump Station and Seasonal Sluice Gate

Optional spring and summer water level and salinity monitoring

Water level monitoring station

Monitor condition of riparian habitat along Class A drainage channels annually.

Continuous precipitation monitoring (location is flexible).

Beach Grove Drainage Pump Station

Continuous flow monitoring by Delta

Deltaport Way
28B Avenue
27B Avenue
28 Avenue
41B Street
52 Street
57B Street
Highway 17A
Falcon Way
Tsawwassen Drive North
21 Avenue
56 Street
Golf Club Drive
17A Avenue
NuLelum Way
16 Avenue
52 Street
53A Street
54 Street
Strait of Georgia (Salish Sea)
Boundary Bay
Tsawwassen Drive South
Pacific Drive
12th Avenue
Kuma Crescent
Siana Drive
Pacific Drive
English Bluff Road
BC Ferries Causeway
8A Avenue

Integrated Rainwater Management Plan

IRMP Monitoring Locations

Figure 5.2

0 250 500 1,000
Meters

U:\Projects_VAN\2177\0040\01\D-Drafting-Design-Analysis\GIS\Projects\MXD\Current\First Report Figures\Figure 3 - Existing Drainage Infrastructure.mxd Last revised by: bpauls on 28/02/2011 at 10:23:53 AM

Readings can be recorded on data loggers at each site or linked via a SCADA system to a computer at the TFN administration office or maintenance building. The monitoring stations and equipment should be checked and maintained at least once a month, at which time data can also be downloaded (if a SCADA system is not installed). TFN staff can be trained to do this maintenance, including the data download if not accomplished by SCADA; alternatively Delta staff or an independent subcontractor/consultant could be engaged to perform this work.

The 28th Avenue irrigation pump station is unique. As an optional item, if reliance on the irrigation pump station is expected to continue, it may be informative to the farming community to monitor summer water levels and salinity. It is anticipated that Delta would lead this aspect of the monitoring program.

Rainwater Management Features

Sections 4.1 and 4.2 outlined guidelines for rainwater management features (RMF's) that should be implemented by developers for various development types, to provide stormwater retention and water quality treatment. Effectiveness monitoring will inform on the success of RMF's implemented at the site level. For at least the first development of each primary land use category (i.e., single family, multi-family, industrial, commercial, etc.) it is recommended that a monitoring chamber be installed on the service connection exiting the site, which houses a sensor and data logger collecting flow and water level information at 5 or 10 minute increments, as well as a multi-probe monitoring system to obtain continuous readings (at 5 or 10 minute intervals) of six water quality indicators:

- pH;
- Temperature;
- Dissolved Oxygen (D.O.);
- Turbidity;
- Salinity; and,
- Conductivity.

To supplement the continuous monitoring, it is recommend that grab samples be obtained monthly at each site, to be analyzed for total and fecal coliform bacteria, and for total and dissolved metals.

As a component of the servicing agreement, it is recommended that the implementation and management of these stations be the responsibility of the developer, with data reporting being supplied to TFN on a monthly basis. Such monitoring should begin upon final completion of the development and span over a one year period at minimum. TFN should also consider re-establishing monitoring after a 5 year period to assess the longer-term performance of RMF's.

Compliance Monitoring

The third form of monitoring will measure the implementation and operation programs. It is proposed that TFN develop appropriate records and processes to make tracking and assessment of this information efficient and effective, as described below.

Implementation Monitoring

The process will be to take inventory of the specific land use and design elements of development sites as they are completed. This will be compiled from both TFN approval records as well as record drawings submitted by the developer. This monitoring will be important as part of the assessment and evaluation process. Suggested measures include:

- Total impervious fraction
- Confirmed application and depth of amended topsoil
- Inventory of bio-retention and other specific rainwater management features
- Catchment boundaries and connectivity of all rainwater management features

Operations Monitoring

On an annual basis, each component of the management system should be inspected to assess its operational condition. Aside from a visual inspection, the monitoring program would vary to suit the component. However, suggested measures will include:

- Does the feature still exist?
- Does the control device still exist?
- Does it appear structurally sound and healthy?
- Does it appear functional?
- Does its performance appear compromised by sediment and debris?
- Is it connected to the broader system as designed?

Development Monitoring

Community records should be established to accurately track the progress of development. The state of development (i.e., land use condition) is calibrated to water quantity and quality monitoring. The interval of this calibration will depend on the rate of development and early monitoring results. It is suggested that a comprehensive GIS database be established to record the following information:

- Development application number
- Development application boundary
- Approved zoning and number of land use units
- All associated record drawings
- Date of completion
- Air photo (as frequent as deemed affordable, but suggested annually)

Validation Monitoring

The fourth and final form of monitoring will be validation monitoring, and is applied at the watershed level to determine if the IRMP goals and objectives of the plan are being achieved. These have been sub-divided into three distinct categories; water and sediment quality, flood protection, and environment.

Water and Sediment Quality

Ideally, monitoring should be done at locations upstream and downstream of TFN lands in order to isolate the effects of activities and land use changes within TFN from those in other parts of the watershed. However, due to the highly interconnected network of ditches within and adjacent to TFN, this is difficult and costly to accomplish. As an alternative, we recommend that permanent water quality monitoring stations be initially established at two locations, immediately upstream of each of the TFN's pump stations (Brandrith; Industrial Lands; with option for monitoring at Deltaport); sediment samples would be taken at these same locations. It is recommended that the stations be established in the near term to collect base line data prior to significant development advancing. Over time, consideration can be given to expanding the monitoring system, either temporarily or permanently, as necessary; particularly if a downward trend is observed; therefore triggering a need to search for, or at least determine, if there is an isolated cause for the decline. After an initial one, or preferably two, year period (as described below), the scope of the monitoring program should be reviewed and adjusted as needed.

The monitoring stations should be outfitted with multi-probe monitoring systems to obtain continuous readings (at 5 or 10 minute intervals) of six water quality indicators:

- pH;
- Temperature;
- Dissolved Oxygen (D.O.);
- Turbidity;
- Salinity; and
- Conductivity.

To supplement the continuous monitoring, it is recommend that grab samples be obtained monthly at each site, to be analyzed for total and fecal coliform bacteria, and for total and dissolved metals. TFN staff could be trained to obtain the samples and deliver them to a laboratory, or an independent consultant could perform the task.

Finally, it is recommend that TFN collect annual sediment samples at these sites, to be analyzed for the same parameters as reviewed during the preparation of the IRMP:

- pH;
- Organic and inorganic carbon;
- Total metals;
- Polycyclic Aromatic Hydrocarbons (PAHs); and
- Extractable Petroleum Hydrocarbons (EPHs).

During periods of significant construction within TFN, the water quality data should be briefly reviewed each month, to catch any problems with the monitoring equipment and identify potential problems in the watershed. All data should then be thoroughly assessed annually by an independent consultant, with an interpretative report provided to TFN.

Flood Protection

In addition to the pump station monitoring described earlier, it is recommended that water levels be monitored within the ditch system at 52nd Street as located on Figure 5.2. For consistency and easy comparison with other monitoring data, it is recommended that this data be collected in 5 or 10 minute increments.

Environment

Ditch and Channel Habitat

Ditches and channels within TFN lands provide important habitat and food sources for aquatic and semi-aquatic wildlife and non salmonid fish populations. Future design should maintain and improve on aquatic habitat where feasible, specifically for Class A ditches and channels. Monitoring of physical condition of riparian habitat within and immediately adjacent to retained or re-located Class A ditches and channels should include:

- Survival of endemic or planted endemic vegetation, so that a minimum of 80% survival rate is achieved for each of the first three years after planting along any new or re-located Class A ditch or channel.
- Degree of invasive species occurrence within the Class A ditches and channels and immediate riparian zone (limits of riparian zone to be established as part of development plan). This can be in conjunction with the endemic plant survival monitoring each year. Actions to remove or manage invasive plant species are to be addressed as part of site management and in keeping with TFN regulations and policies. In addition, amendments to the TFN / Corporation of Delta dike maintenance agreement should be considered to address the control of invasive species.

Intertidal and Marine Habitat

The foreshore and intertidal ecosystem of Roberts Bank is a designated Important Bird Area (IBA) of national and international significance. The IRMP can support the maintenance or enhancement of intertidal and marine habitat integrity by considering the inclusion of environmentally supported features and monitoring the physical state of these. Monitoring activities should include:

- Conduct a pilot project to establish a planting area on the ocean side of the dike, using substrate from the general location. Plantings should be selected from endemic species that are adapted to windblown and saline spray conditions, and should be monitored for a period of three years as to survival and growth.
- For any planted endemic vegetation along the dike, whether part of a pilot project or not, a minimum of 80% survival rate is to achieved for the first three years after planting and should be monitored annually.

5.2.2 Assessment

A typical assessment process is shown in Figure 5.3. This is a standard process involving monitoring, checking results, and then taking appropriate action.

A first step in the assessment process is always to confirm that the data being evaluated "makes sense". For example, turbidity readings of zero would be highly suspect in TFN ditches and may indicate that the instrumentation is malfunctioning or that a monitoring probe has been damaged; such conditions would need to be fixed and new data collected before taking any other remedial or adaptive actions.

Once the validity of the data has been confirmed, a series of questions are asked that can lead directly to various adaptive actions or simply to continue monitoring. As shown in Figure 5.3, one adaptive response that can be considered when data is evaluated is whether the target itself is workable or meaningful; if not, then it should be revised or discarded in favor of one that is more useful.

Action is not required each and every time a target is not met. Rather, action is only required at certain trigger points (e.g., if a target is not met "x" times within a year). This approach will help ensure that TFN makes the best use of limited resources to address the most significant issues within the watershed.

Future comprehensive analysis will remain an important part of the Assessment and Evaluation processes. It is suggested that the predictive hydrologic / hydraulic model be updated after a reasonable amount of development has been implemented and monitoring data collected (estimated two years). Collected data, as described above, would be used to calibrate the model(s) for comparison against predicted models used in the planning process. The model would also be used to make more accurate predictions for future system performance as development proceeds. This approach would allow proactive decisions to be made, rather than reactive.

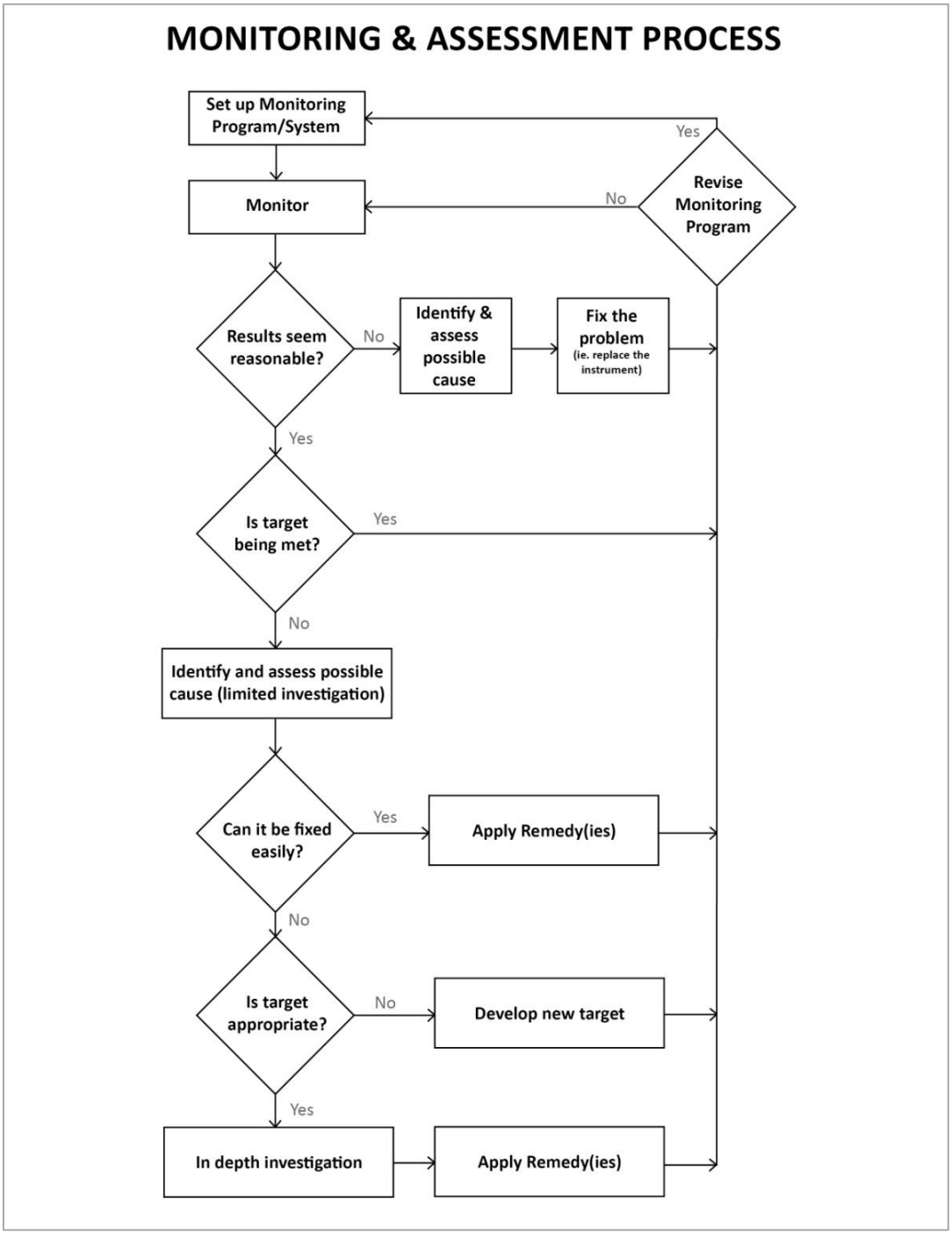
5.2.3 Evaluation and Action Plan

Adaptive management is about taking action to correct problems. Evaluating whether or not the IRMP goals and objectives are being met requires a combined look at the effectiveness and validation monitoring with the compliance monitoring. Should the finding be that performance targets (see Section 5.1) are not being met, it will be important to evaluate whether failure results from inaccurate science and design, or whether there is a failure in the implementation and operational programs. Only from this comprehensive evaluation can effective science based actions be taken. The primary focus of an adaptive management program is to learn from the past and make proactive changes for the future; however, if the evaluation process determines that cost effective retrofits can be made to past installations, such actions would be considered. While recognizably not an exhaustive list, the following sub-sections discuss actions that can be taken to respond to unexpected conditions.

Performance Indicator #1 – Flood Frequency and Extent

Changes in flood frequency and extent can result from both natural and anthropogenic causes. Natural causes include more extreme precipitation and rising sea levels; factors which cannot be controlled. Should these be the determined cause, increased conveyance and pumping capacity is likely the only realistic response. Anthropogenic (manmade) causes can be many, the most likely being:

Figure 5.3: Monitoring and Assessment Process



Insufficient Maintenance of Conveyance Systems

Regular inspection and maintenance programs are necessary to ensure all conveyance systems are free of obstructions and operating at peak performance. In addition, since the conveyance system is highly networked, the removal or change to one element of the system can cause significant impact on others. If the drainage network configuration is not maintained, it should be either re-established, or the overall drainage system should be re-evaluated to determine compensation requirements.

Higher than expected Impervious Area

There is a direct relationship between rainwater runoff rates and volumes, and impervious surfaces. If the extent of impervious areas is tracking ahead of land use plan projections, development approval process should be first reviewed. Are the regulations and development controls being enforced? If not, procedures and processes should be adjusted to ensure they are. If the community (either TFN or Corporation of Delta within their respective jurisdictions) has knowingly allowed development densities to increase beyond the anticipated land use plan and zoning bylaws, then an impact assessment is warranted to assess the effects and re-evaluate infrastructure conveyance upgrades that may be necessary to compensate.

Ineffective Implementation Program of System Upgrades

It will be important that identified system upgrades be done strategically and in advance of development. If the recommended upgrades have been implemented, it may be necessary to conduct additional flow or water level monitoring to isolate the specific deficiency in the system.

Building Practices

Fill placement and perimeter drainage must be managed, as does the setting of minimum building elevations. If problems arise in these two areas, permitting and approval processes should be reviewed and adjusted accordingly.

Performance Indicator #2 - Water and Sediment Quality

While aspects of existing water and sediment quality within TFN lands are already poor, urbanization and agricultural practices could result in even higher concentration of pollutants. Those most likely attributed to urban development within TFN lands include metals, PAH's, turbidity, and EPH's (refer to Section 5.2.1 for further description). Should these values track upwards, more extensive monitoring may be necessary to determine whether the issue is disbursed or acute. Developments should be reviewed for their application and maintenance of RMF's. Regulatory tools may need to be updated and made more definitive and prescriptive. Designs and construction practices of rainwater management features located within communal lands may also need to be reviewed and modified.

Performance Indicator #3 – Open Channel Riparian Health

Should riparian health not be sustained to the desired level, an evaluation of the causes is first required; potential causes include dying of established vegetation, inadequate survival of newly planted stock, insufficient growing media, poor maintenance practices, destructive activities by the public, etc. Potential

actions may include replacement of landscaping, improving maintenance practices, eradicating invasive species, or erection of protective barriers.

5.2.4 Cost Estimates

The following are suggested budgets for the implementation of the physical monitoring and assessment program. Monitoring that is suggested to be the responsibility of development community is not included. Also, costs associated with compliance monitoring are not included.

Precipitation, Flow and Water Level Monitoring

Monitoring implementation costs for the Brandrith and Industrial Lands pump stations (i.e., SCADA and sensors) are not itemized herein as they are considered standard to the design and construction costs of the pump station.

Implementation costs below assume hard wiring, storage kiosks, and remote communications.

Precipitation tipping bucket station (1 site)	$7,500
Water level station at 52nd Street (1 site)	$10,000
Cursory QA/QC review of results (monthly)	$2,400/year

Water Quality and Sediment Monitoring

The estimated costs for the recommended water and sediment quality monitoring program are:

Monitoring station installation, including purchase of multi-probes & data logger (2 sites)	$30,000
Station maintenance & data download (monthly); bacterial sampling & analysis (monthly); sediment sampling & analysis (annually) (2 sites)	$10,000/year
Cursory QA/QC review of results (monthly)	$2,400/year

Riparian Monitoring

The estimated annual cost for riparian monitoring plus monitoring of the dike vegetated buffer pilot project is $10,000-15,000. Once trained, about 75% of the work can be completed by TFN staff, with some assistance or guidance from a consultant.

Intertidal and Marine Monitoring

The estimated cost for a dike vegetated buffer pilot project is $20,000 for the first year, including site preparation, planting materials, planting, maintenance, the first year of monitoring and a brief completion report at year's end. The cost for monitoring in the second and third years of the pilot project is covered by the cost listed for riparian monitoring above.

Compliance Monitoring

Costs associated with compliance monitoring are mainly around establishing tracking systems and records, along with staff time to compile and record data. Dedicated tools and staff specific to compliance monitoring will not be required; rather the needs for compliance monitoring can be satisfied with established tools and staff serving broader duties. The following tools and staff resources are anticipated:

- GIS / Microsoft Access, or similar data tracking software
- GIS technician
- Operations staff to conduct field inspections
- Administration staff to establish and maintain tracking and records systems. These systems will need linkages to various departmental functions; mainly planning / development, engineering / operations, and building / inspections.

It is difficult to put a specific dollar value on compliance monitoring, as it will be influenced by the systems and departmental staff structure established by TFN, and the intensity of community growth. Various staff members will have a role in the program; however the total combined effort to meet the needs of IRMP compliance monitoring should be less than 1 full-time equivalent (FTE) position.

Annual Assessments

On an annual basis, collected data and information will need to be assessed and conclusion reached on whether actions are required. The cost will depend on the data collected, and the findings that result from it. It is suggested that $10,000 be budgeted for this assessment and reporting.

As noted earlier, it is recommended that predictive hydrologic and hydraulic modeling be re-calibrated after sufficient data has been collected and appreciable land development changes have occurred. This is anticipated in three to five years assuming development activities proceed at a reasonable rapid pace. The costs of this update, with reporting are estimated at $20,000. Subsequent updates may also be required in three to five year intervals until build out. It is therefore recommended that a minimum of $7,500, be collected annually to cover these costs.

Cost Summary

Of the items noted above (excluding Compliance Monitoring), approximately $150,000 is required to establish the programs and conduct an initial year's review. Approximately $30,000 to $40,000 per year is estimated to maintain the programs thereafter. Again, this excludes TFN's internal costs associated with administration and records.

Appendix A

List of References

List of References

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